Environmental evaluation of ideas in early phases: a challenging issue for design teams

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Abstract: In early eco-innovation phases, design teams need to assess the environmental relevance of ideas, and consequently, the evaluation stage becomes even more critical, subjective and uncertain than in traditional design. This paper tackles the following question "How to turn elementary ideas into concepts with a high environmental potential in a design team?" Based on eco-innovation literature, we propose to test two methods involving mapping, selection, combination and environmental evaluation of ideas (namely Combineval and Geneval) plus additional free method. Starting with 14 to 15 elementary ideas, three groups of mixed academics and industrials are asked to generate 3 to 5 environmentally relevant concepts on two different test cases. Main results show that there is a large inter-group variability in the evaluation of environmental potential of ideas. Our contribution deals with the systematisation of the environmental evaluation of ideas in early phases thanks to adapted methods and tools. Should the format of ideas be highlighting environmental or a sustainable consideration is one of the emerging issues of the paper.

Keywords: Eco-innovation, Evaluation, Sustainability, Ideas selection, Early design phases.

1. Introduction

Companies need to design more innovative products to compete with each other. To reduce the time-to-market, design teams must be more efficient in their way of generating and selecting relevant ideas. The most promising ideas must be identified as early as possible in the product development process so that the resources are effectively used (Messerle et al. 2012). The idea evaluation is a critical stage of the innovation process (Messerle et al. 2012, Roussel et al 2012, Stevanović et al. 2012) and has a great influence on final products and companies' strategies. It can be defined as the stage where a proportion of concepts are selected for further development whilst often the majorities are rejected (Howard et al. 2010). Designers generally underestimate the importance of selecting the "right product". But as highlighted in Geng et al. (2010), a poor design concept can rarely be offset by later stages.

Moreover, it seems difficult to develop specific and generic methodologies to evaluate and select ideas. Indeed, companies use different creative methods, resulting in different idea formats, and they can perform their creative and evaluation session in groups or individually, with or without an expert (Ferioli et al., 2008). It often results in a subjective and irregular evaluation stage (Amabile, 1983).

Nevertheless, many criteria have been developed to support this evaluation of creative stages and assess ideas, for instance: novelty and quality of generated ideas (Shah et al. 2003); workability of the

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idea ("is the concept socially, legally or politically acceptable"), implementation ("how can an idea be applied from a technical perspective") and relevance (degree from which the concept applies to the problem) (Verhaegen et al. 2013). Systematic methods for the evaluation of ideas are scarce. Literature does not provide any specific tool for a rapid screening process in the early stage of an innovation process (Roussel et al. 2012). If it does, it is too theoretical (Messerle et al., 2012).

Eco-innovation requires to assess the environmental relevance of ideas, and consequently, the evaluation stage becomes more critical, subjective and uncertain (Vallet et al. 2013). It is difficult to find specific research works on the evaluation of ideas in eco-innovation tools. These stages are often associated to a quantitative evaluation, such as Life Cycle Assessment (LCA), streamlined LCA (Hunt et al. 1998), or to more qualitative approaches with various levels of complexity and time-consuming (Bocken et al. 2012). Bocken et al. (2012) stress that although many tools for environmental assessment are available, most of them are bound to be used in the late stages of the Product Design Process.

The aim of this paper is to gain understanding in how to perform the environmental evaluation of ideas in the early phases of the development process, within a design team. The concern is, more precisely to help the team transform ideas into concepts of high environmental potential. Section 2 highlights the current methods and tools for environmental evaluation of: (1) large amount of elementary ideas; (2) limited number of detailed concepts. Section 3 proposes a test of three methods to map, select, combine and perform the environmental evaluation of ideas, based on two test cases. In section 4, the selected ideas and the associated environmental potential are exposed for the three methods. Results are discussed in the light of the participants' feedbacks in section 5. Recommendations and research perspectives towards a successful evaluation of ideas in early phases of an eco-innovation process are given in section 6.

2. Environmental evaluation of ideas in eco-innovation

Eco-innovation is defined as the process of developing new products, processes or services which provide customer and business value and in the meantime significantly decrease environmental impact (Fussler and James, 1996). Therefore, the evaluation stage is also related to the comparison of the performances of the different versions of the product. Consequently, to limit the risk of impact transfer, ideas must also be assessed with a multi-criteria approach according to their environmental relevance all along their lifecycle and during the evaluation stage of the eco-innovation process.

Amongst environmental assessment tools, some of them can be performed during these early stages. Some tools propose an evaluation diagram to compare different eco-innovative concepts, such as the Eco-Compass (Fussler and James, 1996) or the LiDS Wheel (Brezet et Van Hemel, 1997). The QFD (Quality Function Deployment)-based tools which combine the system function with the environmental impact in its reasoning can also be relevant to evaluate ideas (Rahimi and Weidner 2002). Nevertheless, these tools are more appropriate to evaluate more detailed concepts than to evaluate a large number of ideas. Moreover, they only focus on an environmental assessment and not on the creative aspect of the ideas.

If we focus on the evaluation of a large amount of ideas, most of tools are based on self judgment with various criteria. In addition to originality and environmental relevance criteria, Jones (2003) proposes to evaluate the appropriateness, the radical nature and the system levels of the ideas. Tyl proposes to evaluate a social relevance of each ideas (Tyl, 2011), whereas Cluzel introduces the temporality (long and short term) to classify ideas (Cluzel, 2012). In Vallet et al. (2013), two other criteria were examined: the risk of an environmental impact shifting and the potential of a positive influence on the user. The outcome is a first procedure to determine “nugget eco-innovative concepts”.

Complementary to the Eco-Compass, Fussler and James (1996) recommend (1) first to use an “idea matrix” to evaluate the environmental improvement of ideas according to the value that ideas may bring

to the business. (2) Second, to use an “idea score board” to assess the capability of the company to introduce the idea into the market and its competitive advantage of each idea.

A more developed evaluation tool is developed by Bocken et al. (2012). The "Pain Gain Tool" focuses on GHG emissions reduction but is also positioned in a wider set of impacts. The tool proposition deals with an eco-innovation ideas portfolio: quantitatively for impact reduction; qualitatively for business implementation. The tool is used to map the early stages ideas against the "Gain" axis (GHG emissions reduction) and the "Pain" axis (i.e. business implementation).

In line with the previous literature which analyzes the influence of assessment criteria during the evaluation of eco-innovative ideas, this paper specifically investigates the following research questions: (RQ1) How to turn elementary ideas into concepts with a high environmental potential in a design team? (RQ2) What is the influence of the method on the selected ideas and emerging concepts? To do so, we consider that it is possible to propose a method relying on steps of mapping, selection, combination and evaluation of ideas.

3. Empirical setting and test cases

This section presents the rationale of the empirical setting to investigate the process of evaluation and of ideas. The contexts of the two cases providing the elementary ideas for the experiment are also exposed in section 3.2 and 3.3.

3.1. Agenda of the empirical setting

The empirical setting involved 14 participants of a research project, among which 12 members of the French network EcoSD (Eco-design of Sustainable Systems), and 2 volunteering students. The test cases were proposed by two members of the group (a researcher for the prospective case on paper crumpling; an industrial partner for the parking meter case). The constraints for the empirical setting are thus: two case studies, one full day available for experiment and 14 participants. Lessons learned from DRM (Design Research Methodology) imply that one control group is required (Blessing and Chakrabarti, 2009). It was paid attention that the control method should be experienced first in the morning, so that the control groups are not influenced by another method. The designers of the experimental work also identified that each group should experience the two cases in order to be able to compare outcomes. This lead to a quasi-experimental plan, balancing the use of three variants of protocols (method 1, 2 and control method), and two cases A and B during 2 hours each (Table 1). The groups are expected to be equivalent (regarding the balance of experience in eco-design).

Table 1: organisation of the experiment

Group	Organisation of the day	
	Morning (2h)	Afternoon (2h)
Group 1	Control Parking meter (B)	Method 2 Crumpled paper (A)
Group 2	Control Crumpled paper (A)	Method 1 Parking meter (B)
Group 3	Method 1 Crumpled paper (A)	Method 2 Parking meter (B)

The setup involved an initial set of 14 (15) ideas, labelled A1 to A14 (B1 to B15) for case A (case B respectively), see Figure 1 for illustration. The objective is to obtain, by the end of the session, 3 to 5 promising concepts based on the initial set of ideas. The rationale to construct the 3 methodical variants relies on acknowledged pieces of eco-innovation literature, and also on previous research works of the authors.

The control group is free to manage the session, but has to state on the environmental potential of the selected ideas. The environmental potential of an idea is defined as a note/metric which reflects a capacity/number of possible actions to minimize the specific environmental impacts of a specific product. The economic viability and technical feasibility also have to be taken into account, but the evaluation against these criteria is not specifically required.

Method 1 (namely Combineval) is partially inspired by the eco-innovation process based on the Eco-Compass in Fussler and James (1996), although it does not imply any LCA framing. It involves three main steps: (a) a mapping phase of the 14/15 initial ideas along two axes of newness and environmental potential; (b) a combination phase operated by the group along axes of their choice leading to 3 to 5 concepts; (c) a semi-qualitative phase of evaluation of the concepts, based on an adapted version of the Pain Gain tool, where the GHG emissions criterion may be updated by the group (Bocken et al., 2012).

Method 2 (namely Geneval) also embeds three steps, and encourages developing the maturity of ideas. This modification of Fussler and James' framework of is based on several professional feedbacks gained by the authors. After a first mapping (a), participants are expected to mature the 14/15 ideas along the axes of the Eco- Compass (b). For instance, how is it possible to expand an idea dealing with "Use intensity" in order to limit "Health risks"? The 3 to 5 most mature concepts are identified by the group, and evaluated with the customized Pain Gain tool (c), just as in Combineval. The three methods are applied to two types of test cases, defined as follows.

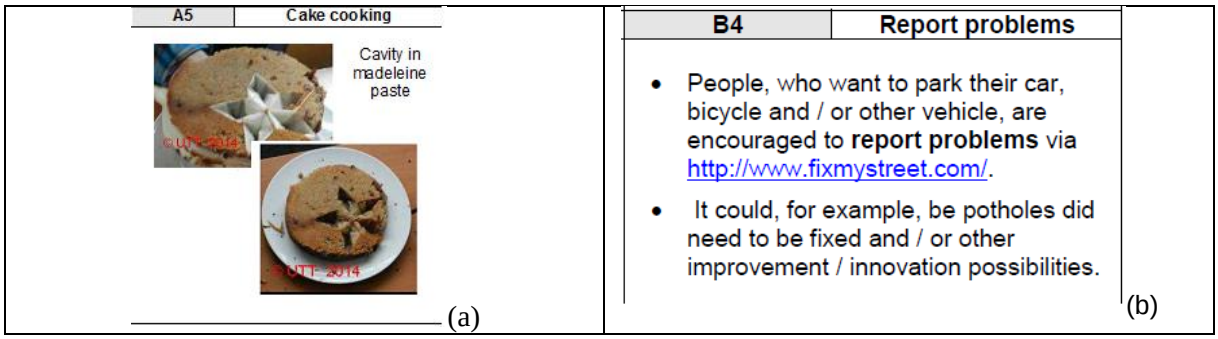

Figure 1: Example of ideas: (a) crumpled paper case; (b) parking meter case

3.2. Presentation of the two test cases

In this section, the main features of the case-studies A and B are presented in details.

3.2.1. Prospective case A: crumpled paper

In this case, the project is to explore the potential of crumpled structures to design innovative packaging for the food industry. The crumpling process is inspired by the origami practice and consists in "a repetitive sequence of a concentric pressure and a reversal of surface applied on a pre-folded paper into a cone shape" (Rohmer and Mérat, 2014). This study aims at verifying if monomaterial paper products are truly more environmentally friendly than other products on the packaging market. The development of new ideas for food applications based on crumpling was conducted with: one team of 4 engineering design students, one professional confectioner and a researcher; and one team of 9 trainers for apprentices in February 2014. Prospective ideas were identified along three main axes: table setting, cooking and manipulation of food. A sample of 14 ideas was extracted for the test from internal project reports and scientific publications. Along with the square cards of ideas, each participant was sent three days in advance a short brief embedding environmental information about cooking applications. For instance abridged results of a LCA comparison between bakery moulds (made of steel, aluminium or silicone) were given in the brief.

3.2.2.Innovative contest case B: parking meter

The parking meter case is based on the outcomes of a crowd-sourcing innovation contest. It was launched by a mobility company in cooperation with the European Commission during spring 2013. This contest, entitled "Imagine a parking meter you love", challenges the public to imagine what useful services parking meters should offer in the future, not only to motorists but also to anyone in the street. The most innovative ideas were awarded by a total prize money of 2,000€. The design brief was labelled as follows: "If you transform a pay and display parking meter into an interactive kiosk, what application or service useful in your everyday life should be available?" Several constraints were added to the brief, such as the proposition should: (1) not affect the appearance of the housing; (2) should be "relevant to a large(r) community"; (3) use one or more [of the terminal's] functionalities; (4) be useful now or in a very near future. The company collected over 480 propositions of services associated with parking meters to be turned into multiservice terminals. Previously to the empirical plan, the propositions were clustered into 62 ideas by the industrial partner. This sample was then reduced to a set of 15 ideas by the leaders of the research group on the basis of their diversity and representativeness of the initial sample, in order to be managed during a two-hour session. Ideas were recorded on Bristol sheets as they appeared in the original file of 62 ideas, i.e. few sentences of text in French or English. Results of the experiment on the two cases are presented in next section.

4. Results

4.1. Environmental evaluation of ideas

As reported in previous sections, three different groups assessed the environmental potential of 14 and 15 ideas related to "crumpled paper" and "parking meter" case-studies respectively. One evaluation was done per group and per case-study. The environmental potential was rated thanks to the following maturity scale:

- 0. No benefits or higher environmental impact compared to existing solutions
- 1. Low environmental potential
- 2. Significant environmental potential
- 3. High environmental potential

As a result, few ideas are rated with a similar environmental potential between the three groups (Figure 2). While B4 (Problems feedback) and B13 (Donation) are unanimously scored as 1 and 2 respectively, results for other ideas are subjected to sometimes large variability. B11 (Payment), for example, is perceived with a high potential by Group 2 while the two others perceived no environmental benefit. The main explanation seems to be the method employed and its own set of environmental indicators. Another way to explain this variability is to focus on the way each group re-appropriated the ideas. As the format of ideas varied from a picture, a verb plus noun, or solely a noun, the different groups re-interpreted the ideas defining different scopes and different end-users.

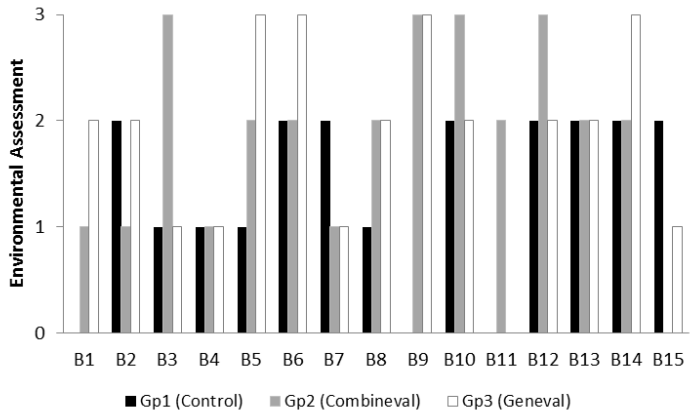

Figure 2: Variability of environmental potential of ideas for the parking meter case

4.2. Selected ideas and emerging concepts

Once the environmental aspect was evaluated, a subset of 6 to 10 ideas per case-study and per group had to be selected by participants. These promising ideas were then discussed and combined by Geneval and Combineval approaches, to provide 3 to 5 innovative concepts. The selected ideas (labelled with a 1) are reported in Tables 2 and 3.

Table 2: Selected ideas for crumpled paper case

Crumpled paper

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	sum
Group 1 (Geneval)					1		1	1	1	1			1		6
Group 2 (Control)	1	1	1	1	1	1							1		7
Group 3 (Combineval)	1			1			1	1	1	1			1		7
sum	2	1	1	2	2	1	2	2	2	2	0	0	3	0	

Table 3: Selected ideas for parking meter case

Parking meter

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	sum
Group 1 (Control)		1		1	1	1	1			1		1				7
Group 2 (Combineval)		1	1		1	1	1	1	1	1	1				1	10
Group 3 (Geneval)			1		1			1	1			1		1		6
sum	0	2	2	1	3	2	2	2	2	2	1	2	0	1	1	

Regarding the "the crumpled paper" case, the two subsets of selected ideas, i.e. 6 and 7 ideas from group 1 and group 3 respectively are quite similar. Indeed 5 of them are shared between those two groups, e.g, ideas A7, A8, A9, A10 and A13. Solely the idea A13 (Cake mould with multiple cavities) is selected unanimously by the three groups. Geneval and Combineval approaches seem to share not only ideas but also the value system that contributes to identify not only the environmental, but also the sustainable potential of ideas. Results on the parking meter case are more contrasted. Only 4 ideas are common between Geneval and Combineval methods (see Table 3). Ideas selection is more distributed according to the method employed. Moreover, the number of ideas retained to be combined is higher for Combineval (10). The mean and the standard deviation of the environmental potential were calculated for each subset. Results are reported in Figure 3.

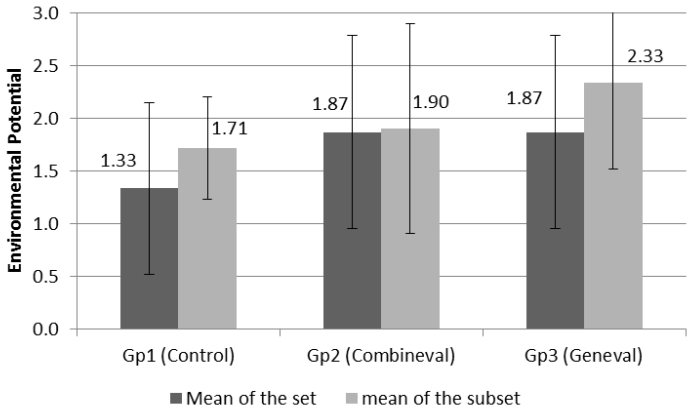

Figure 3: Environmental potential of selected ideas (parking meter case)

Values in black represent the mean of the environmental potential for the entire set of ideas. In light grey, the mean is calculated for the subsets of selected ideas. First and whatever the method employed, the means of environmental potential of the subsets are higher than the means of the initial sets of ideas. In other words, the different groups selected the most promising ideas before combining them into innovative concepts. Geneval and Control approaches seem to be the most relevant methods to capture ideas with the higher potential while Combineval apparently failed to do so. In order to confirm this analysis, a normalized ratio r between the mean of the set and the mean of the subset was calculated as follows:

$$r = \frac{Mj - Mi}{Mi} \quad (1)$$

Where Mj the mean of the environmental potential of the subset of selected ideas (j) and

Mi the mean of the environmental potential of the entire set of ideas (i).

As a result, the lowest score of r is affected to the Combineval approach (0.02). For the two other approaches, r points out an increased value of the environmental potential. Score for Control and Geneval approaches are 0.29 and 0.25 respectively. Unsurprisingly, the control approach is accurate to identify and select the most promising ideas from the entire set of ideas. Values of r for both approaches are quite close; however, the standard deviation for the control method is lower compared to the Geneval approach. Such a result requires to be discussed according to the context. Indeed, while the main goal was to identify and select ideas with high environmental potential in the control group, the Combineval and Geneval groups had to combine ideas into concepts with high environmental potential. Considering that the environmental potential for a concept is not necessarily the sum of each idea's potential, the r index is not relevant anymore to measure the performance of the approach.

5. Discussion

After the experiment, a survey was performed to capture feedbacks of participants on their adhesion to the methods and the performance of the couples (method; maturity of the idea). While the environmental assessment of ideas was obtained per groups, participants' feedbacks were individual. Results are reported and discussed below.

5.1. Level of team adhesion

The level of team adhesion is defined as the individual perception of the ideas selected by the group. Feedbacks were captured through questionnaires and a maturity scale quoted from 0 to 10; 0 representing a low approval and 10 a high approval with the final subsets. The level of adhesion was

expressed and analyzed for the different test cases and the different approaches. Results are summarized in Figure 4.

Detailed results first show that the Control method claims the best scores whatever the case study. Mean values are respectively 9.44, 6.7 and 8.0 for Control, Geneval and Combineval. This result is coherent until the participants defined their own criteria to evaluate the ideas. Geneval and Combival are characterized by lower scores but are highly sensitive to the case study. Indeed, the mean score for the "crumpled paper" case is lower than the score for the parking meter case, 7.04 and 8.92 respectively. In this context, the implementation of the Geneval approach for the crumpled paper is characterized by a low approval (5.00). This statement is partly explained by the difficulties the group encountered while assessing the environmental potential of ideas. The description and maturity of ideas were qualified as irrelevant to reveal it. Excluding this value, the level of adhesion is well scored, e.g. 8.88 and 7.60 for the Control and Combineval method respectively. Compared to the Control approach, the slight difference of adhesion for the two other methods may be explained by the fact that participants are more or less constrained by the methodical framework and the nature of environmental criteria to be used.

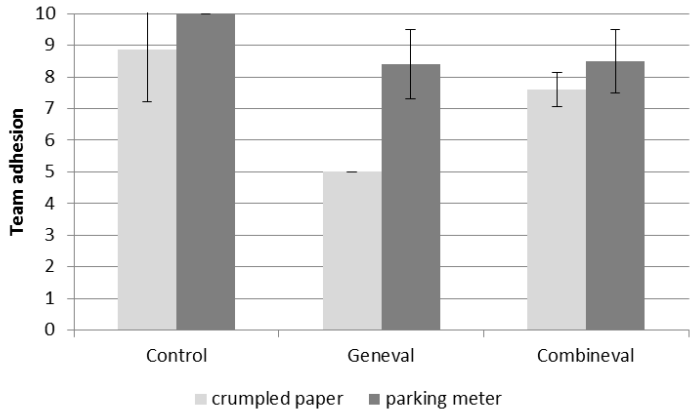

Figure 4: Level of team adhesion for the three methods and for the two case studies

More qualitatively, most of the participants highlight good discussions and the ability to reach a consensus to select ideas. However this statement is mitigated by some participants of the control group (Control method/case B) who consider only a loose consensus was reached. One may consider that it does not seem to be the case with the proposed structured methods 1 and 2; however no one pointed out any strong consensus even so. For some others, the consensus is linked to the composition of the group (influence of the participants) and not to the methods and tools. A consensus may also be found on the evaluation criteria but not on the final ranking of ideas. The consequence is that the most promising ideas from an environmental point of view are probably not selected at the end of the process if they are differently understood by participants. This point is confirmed by Figure 4.

A lever to favour team adhesion is the presence of the project holder or at least someone with a strategic vision of this project. Another lever highlighted in the feedbacks is the presence of tools and graphical representation to have a good traceability of ideas and share a common vision. On the other hand, the control groups have reached a good team adhesion. This point is explained by participants as they all started by collectively defining criteria to assess ideas. The team defines its own framework and its own criteria, which strongly contributes to a personal appropriation. However, the evaluation system built by the two groups is not perceived as discriminating enough, leading to a loose consensus. This is stated by one participant as: *“Is it better to obtain a low-innovative but largely shared solution, rather than a radically innovative but poorly shared solution?”.*

5.2. Evaluation of low maturity ideas

This sub-section focuses on the appropriateness of the assessment methods to evaluate ideas with a low level of maturity. Once again, results reported in the Figure 5 were extracted from feedbacks of participants. The same maturity scale was implemented to score the relevance of methods. 0 represents a high level of irrelevance (or a poor relevance), and 10 a high level of relevance.

As observed in 5.1, results are highly sensitive to the case study. Indeed, mean values for the crumpled paper case vary from 1 to 5.8 for Geneval and Combineval respectively. Regarding the parking meter case, except for the Control approach, results point out a good relevance: 8.4 and 8.25 for Geneval and Combineval. Most of ideas and whatever the case study, were judged as immature. In this context, penalty of assessment is higher for the Control method which aims at selecting the most promising ideas. The framework of the two other approaches makes ideas evolve towards their combination and the emergence of promising concepts. Contexts, end users, usage scenarios are envisaged and continually discussed during the process, which contributes to increase the level of ideas' maturity. As a consequence, a low level of maturity of ideas is less problematic for Combineval and Geneval.

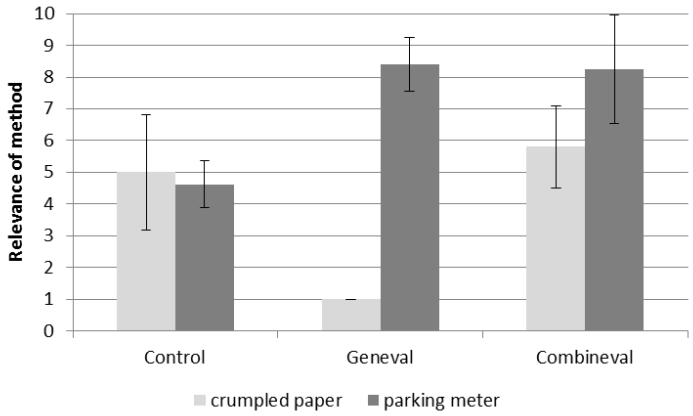

Figure 5: Perceived relevance of the methods for the two test cases

More qualitatively, most of the participants highlight a lack of contextual information to understand ideas and their implications, especially for the ‘crumpled paper’ case. This information concerns different scopes: project history, targeted markets, technical properties (for the different types of paper for example) or usage data. But it is also mentioned that this lack of information is not necessarily a problem. This is part of the maturation and selection process, and it helps the group to share a same vision of ideas. The maturation of ideas is a crucial aspect evoked by numerous participants. It is described as a process to transform ideas into high value opportunities. But this evolution implies, consciously or not, an extension of the initial environmental scope to a broader responsible/sustainable scope. Social aspects have been very quickly integrated by participants during the maturation process, especially for the "parking meter" case. Opinions are also very heterogeneous concerning the facilitation of the environmental evaluation of ideas thanks to this maturation process. For some, the evaluation is easier after the maturation process, but for others it is not.

All the participants without any exception highlight the influence of the format of ideas on the selected concepts. Ideas with pictures are more easily understood, remembered, appropriated and evaluated. Writing some words on a sheet of paper to describe an idea is predominantly not considered as sufficient to understand the entirety of ideas. In the control group with the ‘crumpled paper’ case, ideas without picture have even been dismissed. The format of ideas is hence pointed out as a crucial point to pass on ideas to the different actors and between the different phases of the eco-innovation process.

5.3. Overall perception of the eco-evaluation process

For most of the participants, the proposed evaluation processes are compatible with the upstream phases of the eco-innovation process, i.e. it is possible to give at least a rough evaluation of the ideas. However it is also noticed that the amount of required information and knowledge is critical. A way to compensate for the lack of information is to extract some key contextual elements of the ideas and to interpret them. Of course, it means that the understanding of one particular idea may be different from one group to another, as hypotheses may differ. Another solution is to include in the evaluation group a person who has the knowledge of this context or who has participated to the eco-ideation process. A raising question concerns the necessary interrelation -but also the potential conflict- between the creative eco-ideation phase and the objective eco-evaluation phases. A majority of participants describe the proposed eco-evaluation and eco-selection processes as reproducible. One participant highlights the large difference in the selected concepts obtained with the control group and the more structured methods, which is confirmed by the results analysis. The inevitable influence of the team members on the results is underlined, but it is also noticed that this influence may be minimized by (1) structuring the process (as the influence is higher in the control group); (2) sharing a same understanding or mindset inside the group. To improve the adhesion, a suggestion is to add a stage of collective writing of ideas in order to obtain consensual sheets, description and illustrations, and thus working on the ideas format.

6. Conclusion and future work

The aim of this paper is to provide new insights into an acknowledged issue in eco-design and eco-innovation literature: the environmental evaluation of ideas in early phases of the process. In section 2 it was highlighted that the environmental evaluation of a large amount of ideas and the process to transform them into environmentally viable concepts is poorly documented so far. In order to address the research question "How to turn elementary ideas into concepts with a high environmental potential in a design team?", three methods were constructed, and tested by research groups. The methods involve variants of mapping, selection, combination and environmental evaluation of ideas. Results show that: (1) there is a large inter-groups variability in the evaluation of environmental potential of ideas; (2) in case B (parking meter), Geneval and Control approaches seem to be the most relevant to capture ideas with the higher potential; (3) team adhesion is higher with a free method, but the consensus reached may be loose; (4) dealing with low maturity ideas is less problematic for Combineval and Geneval. A strict comparison between methods (regarding environmental potential, adhesion and relevance of the method) could not lead to significant differences. In fact Geneval and Combineval were used in a very similar way, although initially designed as variants. The observation of participants showed that (1) they could not refrain from maturing the ideas while combining them; (2) the main action of maturation was associated with a combination of ideas. This intertwining of activities seems very typical of the early phases of eco-innovation. The main issue tackled in this paper is not so much which method performs best, than how the participants were able to monitor the selection, environmental evaluation and maturation of ideas into concept thanks to a set of shared environmental/sustainability criteria adapted to the case.

The empirical observations highlight some research perspectives. First of all, the ideas format is infamously evoked as a crucial question and seems an interesting topic for future work. What should be the input (from the eco-ideation stage) and the output (to feed the next steps) formats of an idea? Should this format be specific for eco-innovation by highlighting environmental/sustainable considerations? The presence of visual elements (pictures, photos) is often quoted by participant to impression the understanding of ideas. Another point is the influence of the selection method on the outcomes of the eco-innovation process. It is related to the implementation of eco-innovation methods and tools in industry. We stated in a previous paper a large gap between the development of methods and tools in academia and their appropriation by companies (Cluzel et al. 2014). The identification of the right methods and tools in an eco-innovation process for a given company should contribute to reduce this

important gap. A serious track of investigation would be to work on environmental/sustainability criteria which could be selected and customized depending on the typology of the project.

Acknowledgments

The authors would like to acknowledge the French EcoSD network for its financial support through the Collaborative Research Project 13.4. We also wish to express our gratitude and appreciation to all the project partners, especially to François Humbert, Christian Longet and Serge Rohmer for their contribution during the development of various ideas and concepts presented in this paper.

References

Amabile, T.M. (1983) Brilliant but Cruel: Perceptions of Negative Evaluators, Journal of Experimental Social Psychology 19: 146-156.

Bocken N.M.P, Allwood J.M., Willey A.R.,.King J.M.H. 2012. Development of a tool for rapidly assessing the implementation difficulty and emissions benefits of innovations, Technovation 32: 19–31.

Brezet, H. and Van Hemel, C. (1997) Ecodesign: A Promising Approach to Sustainable Production and Consumption, UNEP, Paris.

Cluzel F., Vallet F., Tyl B., Bertoluci G., Leroy Y. (2014) Eco-design vs eco-innovation: an industrial survey, International design conference – Design 2014. Dubrovnik, Croatia.

Cluzel, F., Yannou, B., Millet, D. and Leroy, Y. (2012) Identification and selection of
eco-innovative R&D projects in complex systems industries, International design conference – Design 2012. Dubrovnik, Croatia.

Ferioli M., Dekoninck E., Culley S., Roussel B. and Renaud J. 2010. Understanding the rapid evaluation of innovative ideas in the early stages of design, International Journal of Product Development 12(1): 67-83.

Fussler C. And James P. (1996). Driving Eco Innovation-A breakthrough discipline for innovation and sustainability. Pitman Publishing, Pearson Professional Ltd.

Jones, E. (2003). Eco-innovation: tools to facilitate early-stage work-shop, PhD Thesis Department of Design,Brunel University.

Geng, X., Chu X. And Zhang Z. (2010). A new integrated design concept evaluation approach based on vague sets, Expert Systems with Applications 37: 6629–6638.

Howard T. J., Dekoninck E. A. and Culley S. J. (2010). The use of creative stimuli at early stages of industrial product innovation. Research in Engineering design (21): 263–274.

Hunt R.G., Boguski T.K., Weitz K. and Sharma A. (1998): Case Studies Ex-amining LCA Streamlining Techniques. International Journal of LCA, Vol. 3, N°1, pp.36–42

Messerle M., Binz H. and Roth D. (2012). Existing problems of idea evaluations and possible areas of improvement. International design conference – Design 2012. Dubrovnik, Croatia.,

Rohmer S., Merat A (2014). Innovative Design of Culinary Moulds based on Crumpled papers, 13th International Design Conference (Design2014), Dubrovnik, May 19-22 2014..

Rahimi, M. and Weidner, M. (2002) Integrating Design for Environment Impact Matrix into Quality Function Deployment Process. The Journal of Sustainable Product Design, Vol. 2, pp. 29–41.

Roussel, B., Bary, R. and Ferioli, M.(2012, Method of creativity including an ideas evaluation tool: application in an international workshop, International design conference – Design 2012. Dubrovnik, Croatia.,

Shah, J., Vargas-Hernandez, N. and Smith, S. (2003). Metrics for measuring ideation effectiveness. Design Studies 24(2): 111-134.

Stevanović, M., Marjanović, D., Štorga, M. (2012) Decision support system for idea selection, International design conference – Design 2012. Dubrovnik, Croatia.,

Tyl, B. (2011) L'apport de la créativité dans les processus d'éco-innovation - Proposition de l'outil EcoASIT pour favoriser l'éco-idéation de systèmes durables, PhD thesis, Université Bordeaux 1, Bordeaux, France.

Vallet F., Tyl B., Millet D. and Eynard B. (2013) A method to select best nuggets from eco-innovation sessions. In Green Design, Materials and Manufacturing Processes, H. Bartolo et al. (Eds), pp 647-654. CRC Press/Balkema, Leiden Netherlands.

Verhaegen, P.A., Vandevenne, D., Peeters, J. and Duflou, J.R.(2013) Refinements to the variety metric for idea evaluation, Design Studies, Vol. 34, pp. 243-263.