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WORKTIME AND CREATIVITY – THE MEDIATING ROLE OF PROBLEM STRUCTURING

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Abstract: The relationship between creative processes and problem structuring (PS - self-interpretation of a problem while solving it) is often overlooked in research. We explored how PS affects the outcome's creativity in the context of two problem types: open or closed presentation, and novelty or usefulness focus. 48 students and architects completed a preliminary design task. Analyses show how outcomes' novelty and usefulness are positively affected by PS under certain conditions, and how worktime indirectly affects creativity through PS. The study offers new insights on the worktime-creativity positive relationship; it opens new directions towards a comprehensive understanding of PS and creativity; and it suggests how both PS and creativity may be promoted through proper time allocation.

Keywords: *worktime, problem structuring, creativity*

1. Introduction

This study explores the creative process and its effect on the creative outcome. More specifically, it examines the role problem structuring (PS) plays in creative problem solving in design. While researchers tend to agree on the positive effect of PS on creativity (e.g., Runco & Okuda, 1988), little is known about how PS influences the creative outcomes (Baer, Dirks, & Nickerson, 2013). Hence, a deeper understanding of underlying mechanisms in the PS-creativity relationship is still needed. We focus on PS as a naturally occurring process by the problem solver, and its effect(s) on the solution s/he provides to the problem. Accordingly, this study has two motivations:

1. *Mapping contextual/personal conditions which affect PS.*
2. *Mapping changes in the effect of PS on creativity under different contextual/personal conditions.*

In this paper we focus on findings and conclusions regarding the indirect effect of worktime on creativity through PS. Additional findings and conclusions regarding the effects of problem types, need for cognitive closure and professional experience are reported in a separate paper.

2. Theoretical background and working hypotheses

Design concerns creative problem solving (Simon, 1969) in search for new outcomes (Hatchuel & Weil, 2009). It is aimed at transforming a given state to a desired state, whose features are partially known. The process ends when a match between a problem formulation and a proposed solution is

achieved (Dorst & Cross, 2001), it is non-linear, and involves iterating cycles of refinements to both problem and solution (Goel, 1994). Along the design process, PS, solution generation and self-evaluation of it take place almost inseparably (Dorst & Cross, 2001), wherein PS serves as a decision criterion for whether, how much and when to follow or abandon a potential solution.

2.1 Problem structuring

Solving ill-structured problems (like in design) calls for interpretations, herein named "problem structuring". It involves the addition or removal of elements to or from the problem, or the complete or partial framing and reframing of it (Goel, 1994; Schön, 1984). Solution generation and elaboration are supported by PS, thus creativity is bolstered as well (Belton & Stewart, 2010). PS is considered fruitful when new insights about the problem are generated, while the consideration of too narrow or too wide a set of options is prevented (Mitroff, 1997). In addition, PS helps in balancing between decreasing and increasing complexity, such that a manageable situation is achieved on the one hand, and contents breadth is secured on the other (Badke-Schaub & Gehrlicher, 2003).

Kruger and Cross (2006) name two principal approaches designers adopt during problem solving. Unlike solution driven designers, those holding a problem driven approach invest effort in defining the problem. They gather information in reaction to a perceived need for PS, with an aim to deepen their understanding of the design requirements and constraints (Restrepo & Christiaans, 2004).

Yet, PS may also have a negative influence. When designers engage in PS, they habitually deviate from initial declared requirements. This deviation entail deferring commitment to a solution (Goel, 1994), though such a commitment is central to creativity (Amabile, 1988). Correspondingly, Atman et al. (1999) found a negative correlation between the time spent on PS and the quality of a solution. This was attributed to insufficient attention to solution development due to prolonged PS. Thus, devoting too much effort to PS may impede creativity, even though PS generally increases it. Hence:

H1 *The relationship between PS and creativity is non-linear, and has an inverse U curvilinear shape, where extremely low and extremely high levels of problem structuring bring about decreasing levels of the outcome's creativity.*

2.2 Worktime

Research agree on a positive worktime-creativity relationship, wherein unique ideas come last, and take longer to attain (e.g., Mednick, 1962). Time, though, is not always a predictor of remote ideas, and quantity does not always breed novel ideas (e.g. Reinig & Briggs, 2008). An alternative explanation to the worktime-creativity relationship suggests that incubation facilitates better selection of ideas and more effective elaboration (Baird et al., 2012). However, another explanation exists.

Drawing on timescape theory, which highlights the importance of time management in structuring the task (e.g., Halbesleben, Novicevic, Harvey, & Buckley, 2003), we pose that the more a given timeframe is used for PS, the more novel and useful outcomes will be. Hence:

H2 *Problem structuring mediates the worktime-creativity relationship, such that a longer worktime will result in higher PS and will positively affect the outcome's creativity.*

2.3 Intervening factors

Chirumbolo et al. (2004) show how Need For Cognitive Closure (NFCC) - one's sense of urgency to reach a solution (Webster & Kruglanski, 1994) - is negatively correlated with creativity, and hence is controlled for in this study. Goldschmidt and Smolkov (2006) demonstrated how a problem's perceived inherent focus, either novelty or usefulness, affects the outcome's creativity, with novelty-focus problems resulting in higher creativity ratings. Similarly, problems presented in an open mode (non-specific), rather than a closed mode (specific), result in higher creativity ratings (Chand & Runco, 1993). Hence, both problem types are controlled for in the current study.

3. Method

51 architects and students of architecture (in their 3rd to final year) were recruited from industry and accredited schools, and were asked to reach a preliminary solution to a design problem, yielding 48

legitimate outcomes (63% females, 14 students, 11 architects with 1-5 years' experience, 12 with 6-10 years' experience, 11 with more than 10 years' experience). All the participants were proficient in Hebrew, volunteered to the study, and payed the equivalent of US$ 14 for their participation.

3.1 Measures

PS was measured using protocol analysis. Video recordings of the design sessions were parsed into design moves and coded for each participant. A design move was the length of a sentence or a part thereof which represented a single coherent line of thought (Goldschmidt, 2016). Consolidating findings by Goel & Pirolli (1992) and Atman at al. (1999), a coding scheme was formulated to distinguish problem related moves from solution related ones, or those related to self-evaluation of a design state. Indicators of PS include: a) references to users and modes of use; b) signs of information seeking; and c) signs of deferring commitment. An overall score of PS was computed as a sum of the problem related moves, divided by the overall number of design moves. Recordings were coded by three independent naïve evaluators. Inter-rater reliability score was ICC_2>0.80.

Creativity ratings were provided by three expert judges who were blind to the research objectives and conditions. They independently assessed all the proposals, while instructed to neglect graphic quality in their assessments. Novelty (uniqueness and added value averaged per participant) and usefulness (addressing requirements and feasibility averaged per participant) were independently assessed on a between-participant comparative basis, using a 7-point Likert scale. The judges collectively rated 10% of the proposals first, to calibrate scoring criteria. Conflicting assessments were arbitrated, arriving at an inter-rater reliability score of ICC_2>0.95.

A Theme identification procedure served to gain deeper understanding of individuals' intentions along the design process, by analyzing participants' answers to the following open debriefing questions: "what was the most important decision you made?", "what were the most difficult and the easiest aspects of the design process?", "what information was missing?", and "what considerations guided your design process?". Coding categories, derived from the answers, include among other: problem related issues, physical features of the outcome, experimental setting, and idea generation. Final coding was then conducted by three independent judges, arriving at a list of 290 legitimate data points, with an inter-rater reliability score of *Fleiss'* κ>0.82.

The following controls were established: gender, age (in years), professional experience, NFCC, and problem types. Professional experience was a multi-categorical variable with four levels, from students to professionals with over 10 years of experience. NFCC was measured on the 15 items short Hebrew index by Tadmor et al. (2012). A sample item is: "I may lose my patience and become irritated very fast if I don't find an immediate solution to a problem". To meet satisfactory reliability, statistical analysis was conducted on 12 items, which did not affect aggregated NFCC scores. Reliability score for the 12 items was *Cronbach's* α>0.80.

Problem types were manipulated through the design briefs presented to the participants. Two design tasks were devised. Each was presented in one of two versions – open (2 design requirements) or closed (7 design requirements). A novelty focus task called for the design of a memorial in mid sea for those who perished in marine disasters. A usefulness focus task called for the design of a compound for three panthers in captivity. Overall there were four experimental conditions. The tasks were tested in a pilot study, adapted to the time limit, and allowed participants with varying professional experience to arrive at adequate solutions. Three naïve expert architects and participants in the pilot study accurately classified the problems into the experimental conditions.

3.2 Research design

An experimental design of a two (open/closed problem presentation) by two (novelty/usefulness problem focus) factorial design was chosen. Participants were randomly assigned to one of four experimental conditions (n=12 in each), while keeping age, professional experience and gender balanced between conditions. They participated in the study on an individual basis, for about 1.5 hour, based on their individual pace. Each participant completed a single preliminary design task. Biographical data and ratings of the NFCC index were collected first. Participants were then given

instructions for a preparatory task, and subsequently for the design task. Last, participants were asked to answer debriefing questions.
Working on their design proposal, participants were videotaped and directed to think aloud. After completing the preparatory task (5 min., design of a lottery tickets selling booth), participants were allotted 30 minutes to work on their design proposal. They were free to terminate the design process earlier and were instructed not to use the 30 minutes for preparing the proposal for assessment (10 additional minutes were allotted for that). Submissions included sketches and text at will; nevertheless, at least a plan, an elevation, or a perspective sketch was mandatory.

3.3 Data analysis

Process' model 14 and 18 for SPSS (Hayes, 2013) were used to test effects on novelty scores and on usefulness scores respectively. All the direct and indirect effects were tested at once, with 5,000 bootstrapping resamples to set 95% confidence intervals around the estimates. An analysis of the theme identification data was carried out according to five median splits of the sample: a) worktime; b) NFCC; c) PS; d) novelty scores; and e) usefulness scores. The reported results for these comparisons are the sum of references made by all participants in each cell of the comparison, setting a ratio between the number of references in the lower and the higher halves in each median split.

4. Results

4.1 Descriptive statistics

28 participants used between 10:45 and 29:50 minutes, while the other 20 exploited the entire 30 minutes (M=24:08, SD=6:43). PS scores ranged between 45% for low PS and 75% for high PS (M=59%, SD=7.2%). NFCC scores ranged between 2.08 for a low NFCC and 4.67 for a high NFCC (M=3.39, SD=.61). Worktime, PS and NFCC scores were standardized for statistical analyses. NFCC was also reverse coded, such that high scores meant a low NFCC. Novelty scores ranged between 1.17 for low, and 7 for high novelty (M=3.02, SD=1.44). Usefulness scores ranged between 1 for low, and 6.17 for high usefulness (M=3.79, SD=1.18). See Table 1 for descriptive statistics.

Table 1. Descriptive statistics and Bivariate Pearson's correlations between experimental variables

	M	***SD***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	37% males												
2	33.33	9.45	0.47**										
3			0.44**	0.78**									
4	*n*=12		-0.05	-0.02	0.17								
5	*n*=12		-0.05	-0.07	-0.13	-0.33*							
6	*n*=12		-0.05	0.01	-0.08	-0.33*	-0.33*						
7	*n*=12		0.15	0.08	0.04	-0.33*	-0.33*	-0.33*					
8	24.08	6.43	-0.21	-0.35*	-0.29*	0.04	0.04	-0.07	-0.01				
9	3.39	0.61	0.22	0.27	0.27	0.24	0.07	-0.09	-0.22	-0.01			
10	0.59	0.07	-0.05	0.06	0.14	0.09	0.06	-0.11	-0.04	0.29*	0.05		
11	3.02	1.44	0.10	-0.06	0.08	0.01	0.37**	-0.20	-0.18	0.29*	0.35*	0.30*	
12	3.80	1.18	0.17	0.20	0.40**	0.30*	-0.16	0.08	-0.22	-0.20	0.22	0.02	-0.03

**. Significance level is $p \leq 0.01$ (2-tailed).

*. Significance level is $p \leq 0.05$ (2-tailed).

1) Gender (males=1); 2) Age (years); 3) Professional experience (4 groups); 4) Novelty-closed problem; 5) Novelty-open problem; 6) Usefulness-closed problem; 7) Usefulness-open problem; 8) Worktime (Z); 9) NFCC (Z, reversed); 10) PS (Z); 11) Novelty scores; 12) Usefulness scores

Bivariate Pearson's correlations between the experimental variables show a positive and significant relationship between worktime and PS (r=0.29, p<0.05), as well as between worktime and novelty scores (r=0.29, p<0.05). A significant relationship between professional experience and usefulness

scores was also observed (r=0.39, p<0.01). Novelty-closed problems were positively and significantly related to usefulness scores (r=0.30, p<0.05), while novelty-open problems were positively and significantly related to novelty scores (r=0.37, p<0.01). Age and gender were not related to the experimental variables after controlling for covariance between age, gender and professional experience (see Table 1 for correlations).

4.2 Hypotheses testing

Hypothesis 1 suggested that the relationship between PS and creativity has an inverse U curvilinear shape. A curve estimation analysis of the relationship between PS and novelty and usefulness scores did not yield a better fit than the linear models (p<0.04, R^2=0.09 for novelty scores and p=0.89$_{n.s.}$, R^2=0.00 for usefulness scores). Hence, hypothesis 1 is not supported.

In light of the observed correlations with problem types, NFCC and professional experience, the final model was modified such that: a) the effect of worktime on both novelty and usefulness scores is mediated by PS; b) the relationship between PS and usefulness scores is moderated by problem types; and c) the relationship between PS and novelty scores is moderated by NFCC.

A regression of PS on worktime reveals a positive and linear effect of worktime on PS (b=0.29 (0.14), p<0.05, R^2=0.08). The direct effects of worktime on novelty and usefulness scores, with PS as a mediator, are insignificant (b=0.24 (0.18), p=0.20$_{n.s.}$ for novelty scores, and b=-0.25 (0.18), p=0.17$_{n.s.}$ for usefulness scores), which point to a potential full mediation, supporting hypothesis 2.

The conditional effect of PS on usefulness scores with problem types as a moderator while controlling for professional experience is significant ($F_{(11,36)}$=2.38, MSE=1.06, p<0.03, R^2=0.42). Hence, the indirect effect of worktime on usefulness scores is mediated by PS when the initial problem formulation is usefulness-open (see Table 2). The conditional effect of PS on novelty scores with NFCC as a moderator while considering the main effect of problem types is significant ($F_{(7,40)}$=4.24, MSE=1.41, p<0.01, R^2=0.43). Hence, the indirect effect of worktime on novelty scores is mediated by PS when NFCC is low (see Table 2).

Table 2. Conditional indirect effects of worktime on usefulness and novelty scores, mediated by PS

	Outcome: PS	**Outcome: Usefulness scores**			**Outcome: Novelty scores**		
		Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Exp.1: students [a]		-1.13* (0.46)	-1.18* (0.47)	-1.11* (0.45)			
Exp.2: beginners [a]		-0.36 (0.49)	-0.53 (0.50)	-0.38 (0.48)			
Exp.3: intermediate [a]		-0.40 (0.46)	-0.50 (0.50)	-0.49 (0.47)			
Pr.Presentation [b]		-0.65 (0.32)	-0.65 (0.45)	-0.54 (0.43)			
Pr.Focus [c]		0.24 (0.32)	0.31 (0.46)	0.34 (0.44)			
Pr.Pres x Pr.Focus			-0.08 (0.65)	-0.11 (0.62)			
Pr.Usefulness-closed [d]						-1.15* (0.51)	-1.20* (0.49)
Pr.Usefulness-open [d]						-1.08* (0.51)	-1.06* (0.49)
Pr.Novelty-closed [d]						-1.06* (0.51)	-0.99* (0.49)
NFCC (Z, reverse)					0.50* (0.19)	0.46* (0.19)	0.44* (0.18)
Worktime (Z)	0.29* (0.14)	-0.14 (0.18)	-0.19 (0.19)	-0.25 (0.18)	0.33 (0.20)	0.32 (0.19)	0.24 (0.18)
PS (Z)		0.03 (0.18)	0.12 (0.30)	-0.21 (0.33)	0.31 (0.20)	0.28 (0.19)	0.33 (0.18)
PS x Pr.Pres			0.38 (0.35)	1.15* (0.49)			
PS x Pr.Focus			-0.52 (0.33)	0.18 (0.45)			
PS x NFCC							0.36* (0.17)
PS x Pr.Pres x Pr.Focus				-1.35* (0.63)			
R^2	0.08*	0.28*	0.35	0.42*	0.25*	0.36*	0.43*
ΔR^2			0.06	0.07*		0.11	0.07*
N	48	48	48	48	48	48	48

*. Significance level is $p \leq 0.05$ (2-tailed).

a. Reference group for professional experience is 4 - experts.

b. Reference group for problem presentation is open presentation.

c. Reference group for problem focus is novelty focus.

d. Reference group for problem types is novelty-open problem.

4.3 References to themes analyses

The analyses of participants' references to themes revealed that most of the references were made to problem related issues (25%), then to physical features of the outcome (21%), and third to the experimental setting (14%). None of the remaining themes were referenced over 10% each.

Participants who were lower in PS referenced issues related to physical features of the outcome (issues not related to the problem) considerably more (42 times) than participants who were higher in PS (23 times). Those who were lower in PS stated that the most important decision they made was related to physical features more than those who were higher in PS (13 vs. 7 times respectively). Similarly, those who were lower in PS stated that information about the expected physical features of the outcome was missing more than those who were higher in PS (16 vs. 10 times respectively).

Following the trend in the statistical analysis, a positive effect of worktime on PS was revealed in the theme analysis. Participants who spent more time on task referenced problem related issues more than participants who spent less time on the task (47 vs. 29 times respectively). In addition, participants who spent more time on the task referenced problem related issues as design motivators more (18 times) than individuals who spent less time on the task (10 times).

Participants who received higher novelty scores referenced problem related issues as design motivators more than participants who received lower novelty scores (17 vs. 11 times respectively). This result echoes the positive effect of PS on novelty scores. It also provides further ground to the mediating role of PS on the worktime-novelty relationship, when combined with the relationship between worktime and the likelihood to report problem related issues as design motivators.

5. Discussion

This study contributes in bringing together two research paradigms – design research and organizational psychology, to highlight the role of PS in the creative process. First it demonstrates the effect of PS on both the novelty and the usefulness of the outcome, and second it reveals that designers who spend more time on the task are more involved in PS than in solution generation and elaboration (and self-evaluation). It is important to stress that designers who are highly engaged in PS do so deliberately and can report on it, as is shown in the theme analysis. Moreover, they find PS important in their design process. Hence, they are willing to defer commitment to a solution (Goel, 1994), and rightfully so. Higher PS results in more novel and useful outcomes.

5.1 Problem structuring mediates the worktime and creativity relationship

Designers whose worktime is longer engage more in PS and thus develop a solution with better creative results. The current study opens a new perspective on the worktime-creativity relationship by: a) showing the positive effect of worktime on creativity in natural tasks, b) explaining the underlying mechanism of the worktime-creativity relationship through the mediating role of PS.

This study provides an alternative explanation to sub-conscious processes regarding the worktime-creativity relationship (e.g., incubation - Reinig & Briggs, 2008). Here, designers whose worktime was longer tended to invest time in problem related design moves, thus achieving a more creative outcome. Conversely, the relationship between the percentage of design moves related to the solution and between worktime or the outcome's creativity was negative. Participants' verbalizations along the design process provide further evidence. In several cases, after arriving at an initial satisfactory solution, participants asked themselves how to advance, considering that there is sufficient time left; they then continued to readdress the problem, not to promote the solution.

Our findings expand Savage's et al. (1998) observations that when no time constraint is set, it takes longer for designers to provide a solution, as they spend more time on understanding the problem. We thus conclude that the positive effect of worktime on creativity is not independent of usage of available time, in terms of the category to which design moves belong (either problem or solution).

5.2 Moderations on the problem structuring and creativity relationship

We show how PS enhances the outcomes' usefulness for usefulness-open problems. Moreover, we show antithetical findings to the professional experience and PS positive relationship suggested in

research (Björklund, 2013), in demonstrating how the outcome's usefulness is contributed by PS above and beyond the positive effect of professional experience under such a condition.
Research shows that ten years of experience are needed to produce high quality (expert) architectural design (Akin, 1990). Altogether, experts display a more proactive attitude towards PS, which allows a more efficient problem solving process (Björklund, 2013). However, in the current study professional experience was shown to have an effect only on the outcome's usefulness and not on the outcome's novelty. Most importantly, PS was independent of professional experience in our study, and had a positive effect on both usefulness and novelty under appropriate conditions.
Last, with a low NFCC, individuals achieve greater novelty the more they engage in PS. Interestingly and counter intuitively, NFCC had no direct effect on worktime or PS (Kruglanski, 2004). An examination of the PS-novelty relationship discloses the role of a low NFCC as a boundary condition for producing novel outcomes. This role is suggested by previous research (Chirumbolo et al., 2004), and is manifest in the moderating effect of NFCC on the relationship between PS and novelty scores.

6. Limitations and future research

Personal traits may affect creativity and PS. However, two important ones - openness to experience and tolerance for ambiguity, are accounted for in the NFCC construct. Next, generalizability is limited due to the small sample size and a disciplinary homogeneity. Additionally, the experimental setting does not mimic real life design conditions, including the timeframe. Half an hour causes a ceiling effect. Furthermore, it is not comparable to task durations of hours, days or weeks, thus it is important to qualify the findings to matching timeframes. The experimental setting may have also intervened in cognitive processes, hence triggering attention to either the problem or the solution, or to representing the proposed outcome.
Future research should manipulate both worktime and PS. In addition, PS should be explored in different contexts, mainly in teams and across disciplines. Finally, future research should help identify the curvilinear relationship between PS and creativity, which is plausible and was not observed in the current study, probably due to the 30 minutes' time limit common in laboratory experiments.

7. Conclusions

PS is probably not immune to possible effects of the problem solver's uncontrollable prior state (knowledge, professional experience, personal traits). Worktime is nevertheless a controllable factor that significantly promotes PS and consequently, creative achievement. However, a curvilinear relationship is anticipated for longer than 30 minutes task durations. This is not only a development in what is known about the worktime-creativity relationship; it is also an opportunity to highlight the importance of allocating adequate time for creative processes (Amabile et al., 2002), but with an emphasis on using this time for understanding and reframing the problem. Approaching PS this way may assist in guiding designers at any stage of their professional formation and career. This with an understanding that PS promotes creativity above and beyond elaboration of the solution. What is more, PS stimulates creativity regardless of professional experience and hence may assist novices in arriving at high quality solutions.

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