Creativity and Successful Product Concept Selection for Innovation

Günther, Agnes; Eisenbart, Boris; Dong, Andy

Document Version
Accepted author manuscript

Published in:
International Journal of Design Creativity and Innovation

DOI:
10.1080/21650349.2020.1858970

Publication date:
2021

License
Unspecified

Citation for published version (APA):
Günther, A., Eisenbart, B., & Dong, A. (2021). Creativity and Successful Product Concept Selection for Innovation. *International Journal of Design Creativity and Innovation*, *9*(1), 3-19. https://doi.org/10.1080/21650349.2020.1858970

Creativity and successful product concept selection for innovation

Guenther, Agnes[a]*, B. Eisenbart[b] and A. Dong[c]

[a]Department of Strategy and Innovation, Copenhagen Business School, Frederiksberg, Denmark; [b]Department of Industrial and Architectural Design, Swinburne University of Technology, Melbourne, Australia; [c]Mechanical Engineering Department, Oregon State University, Corvallis, USA

Declaration: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The usual disclaimer applies.

Agnes GUENTHER* (corresponding author)

agu.si@cbs.dk, https://orcid.org/0000-0002-2069-3145

Kilevej 14A/B, K.2.46, 2000 Frederiksberg, Denmark,

Phone: +45 3815 3346

*This is an Accepted Manuscript of an article published by Taylor & Francis in The International Journal of Design Creativity and Innovation, available online: http://www.tandfonline.com/*10.1080/21650349.2020.1858970.

Creativity and successful product concept selection for innovation

Selecting novel product concepts for further development into successful innovations entails decision making under conditions of high uncertainty. The literature discusses several influencing factors for making accurate decisions in such situations, such as domain expertise to evaluate technical feasibility and market potential. Recent scholarship increasingly highlights the decision makers' personal creative capabilities to have an important influence in dealing with uncertain options. This article examines an individual's creativity and its relation to the individual's propensity to select novel product concepts and to choose product concepts correctly for further development. We present an experimental study showing that an individual's level of creativity increases the likelihood of accepting novel product concepts without negatively affecting decision accuracy. Domain expertise operationalized as familiarity with the intended, central use case or technology in the product concept neither influences the likelihood of accepting new product concepts nor decision accuracy. These findings have strong implications for companies in relation to managing individuals selecting product concepts for further development in early stages of the innovation process.

Keywords: Creativity; Decision making; Concept selection; Opportunity recognition; Abductive reasoning

Introduction

In recent years, market turbulence has challenged companies to create profitable growth through good strategic investment decisions. A large potential for the acquisition of capabilities and resources to set oneself apart from competitors can come from early entry into or creation of novel markets through investment in innovative technologies, products, or service offerings (see Lieberman & Montgomery, 1988). Novel, unprecedented – and thus hardly predictable – innovation opportunities create conditions of extreme uncertainty in which decision-makers must choose a few opportunities from a portfolio of choices since the company cannot pursue all

opportunities. Screening early-stage innovation opportunities for further development is a type of decision that entails the selection of options that have risks and uncertainties that classify as *unknowable* (Diebold, Doherty, & Herring, 2010; Huang & Pearce, 2015). The psychology of making such selections successfully remains understudied and is not fully understood (Eling, Langerak, & Griffin, 2015) especially at the instance of the go/no-go decision even though it is acknowledged that effective screening of concepts has a high correlation with new product performance (Cooper & Kleinschmidt, 1986).

More and more research points to the cognitive strategies applied in understanding, sense-making, and framing of an opportunity to influence the accuracy of selections under extreme uncertainty (Narayanan, Zane, & Kemmerer, 2011). Expanding on this line of research, in the work presented here, we investigate how an individual's level of creativity affects the selection of novel product concepts that could potentially be turned into innovations through further development, both in regard to acceptance as well as the accuracy of the decision. An understanding of how the level of creativity affects the selection of novel product concepts could have important implications for screening innovation opportunities. Prior research has shown that the quality of the raw concepts and their subsequent market success are strongly correlated (Kornish & Ulrich, 2014), suggesting that the evaluation and selection of early stage product concepts can propel an organization's overall performance.

A core position in scholarship on these sorts of selection processes is that the individuals tasked with making the decision should have domain expertise about the technology and target use case (i.e., central intended application) of the novel product concepts in the target markets. Scholars argue that this type of knowledge influences the way an individual searches (Fiet, 1996) and recognizes potentially profitable

opportunities to create new goods and services (Shane, 2000). This is opposed to, e.g., novices or potential customers who may not have relevant knowledge and have been found to favor solutions featuring less novelty and known patterns (Leder & Carbon, 2005; Rogers, 2010). While we agree that a degree of domain expertise is necessary, we believe that the level of creativity of the individuals assessing novel product concepts might explain some of the variance. High levels of creativity increase an individual's ability to generate vivid simulations and representations of the future situations (Peters & Büchel, 2009) in which the product concept could exist as a successful innovation in the market. In such a situation, creative cognition may become useful to imagine future scenarios and novel hypotheses that explain how product concepts might generate commercial value if those hypotheses turn out to be true (Delas, Maranzana, Mantelet, & Buisine, 2015; compare Dorst, 2011; Gonzalez & Haselager, 2005). The cognitive strategies that are vital for creative cognition (Finke, Ward, & Smith, 1992) may thus be relevant in selecting potentially innovative product concepts because they help individuals to generate synthetic information that they would otherwise overlook when faced with complex cases and no opportunity for further data collection, also known as the so-called "what you see is all there is" bias (Kahneman, 2011). Berg (2016), for instance, illustrates the potential of cognitive strategies rooted in creative thinking to increase the accuracy of predicting the success of novel ideas in spite of the uncertainties associated with them. Similar arguments and supporting data are presented in research on entrepreneurship (Huang & Pearce, 2015), innovation (Assink, 2006), and design (Dong, Lovallo, & Mounarath, 2015). Dong et al. in particular argue that the presented idea (or concept) itself should serve only as a starting point, rather than the singular basis of information for making the decision. They propose that making choices of uncertain options in product development should – by nature – use creative

forward thinking to envision the utility, or value, of future opportunities. Being able to envision alternative futures more vividly may then motivate individuals to pursue an idea (Haynie, Shepherd, & McMullen, 2009; Juliusson, Karlsson, & Gärling, 2005). We thus hypothesize that highly creative people are more likely to accept novel product concepts than less creative individuals. Furthermore, we are interested in which part of creative cognition affects individuals' selection of novel concepts. To answer these questions, we draw on prior research on creativity and abductive reasoning to examine their influence on the acceptance rate and success of selected product concepts. We then present an experimental study of individuals selecting real-world novel product concepts for further development into commercial products. We specifically focus on the moment during which individuals evaluate and select novel product *concepts* that could be turned into non-incremental innovations, and the creative capabilities of the individuals, rather than the process for making these selections. The product concepts examined in our experiments would, if successful, most likely lead to radical or modular innovations as defined by Henderson and Clark (1990). It is acknowledged that organizations in practice may involve individuals from various disciplines and educational backgrounds, such as design, engineering or marketing (e.g., Melcior & Eisenbart, 2017), in the selection of novel product concepts for further development. The decisions we focus on in this article are about concepts that are in their early stage with limited discipline-specific information about potential markets, technical feasibility, which is common in the Fuzzy-Front-End of innovation. Participants were tasked with deciding either to fund further development of the product concepts presented to them or waive on them. We strived to investigate differences in the likelihood of accepting novel product concepts and decision accuracy based upon the level of creativity of the participants. Therefore, the focus of this paper is on the link

between individual creativity and the selection of novel and potentially valuable product concepts.

In the following sections, we first review extant literature on creativity and related cognitive processes, such as abductive reasoning, to form the hypotheses tested in our research. Then we present our study and the obtained findings. We discuss our results and conclude with implications for practice and future research.

Creativity in Concept Selection Processes

Creative thinking in reasoning and decision making

At the heart of decision making about a new product concept is a belief that a plausible (future) situation exists in which the new product concept can have commercial value. Since more creative individuals tend to produce more creative product concepts, so too it could be reasoned that they should be able to imagine situations in which the product could be successful. Behavioral studies establish that creative experts succeed at engaging in vivid distal simulations, compared to less creative individuals (Lee, Gu, & Ostwald, 2015; Meyer, Hershfield, Waytz, Mildner, & Tamir, 2019). The underlying hypothesis is that more creative individuals tend to remain *open-minded* to the potential value of novel ideas (Berg, 2016; Dong et al., 2015; Mounarath, Lovallo, & Dong, 2011). They engage in vivid episodic foresight, the act of foreseeing a future event or acting with reference to the future (Suddendorf, 2010), to generate better cognitive representations (Gavetti & Levinthal, 2000) about future situations before taking decisions. Entrepreneurship research (Hansen, Lumpkin, & Hills, 2011; Haynie et al., 2009) shows that more creative entrepreneurs more vividly envision a potential future in which the opportunity *was* exploited and then became highly motivated to purse an opportunity deemed viable, more so than less creative individuals. The uncertainty of

these future scenarios will likely spur individuals to 'run' spontaneously a dynamic mental model to determine the cause-effect relationship between the product concept and the commercial value in the imagined situation (Ball & Christensen, 2009; Nguyen & Zeng, 2017).

In contrast, applying predominantly causal, prediction-based decision-making logics – such as rule-based or purely metrics-based thinking in evaluating the potential of a novel product idea – can suppress the quest for novel solutions that may turn into successful innovation. This is supported through empirical work by Dew, Read, Sarasvathy, and Wiltbank (2009), Rottenstreich and Kivetz (2006) showing that more successful decision makers in a business environment tend to use significantly higher amounts of complementary cognitive frames in evaluating a potential novel opportunity. Complementary cognitive frames combine explorative, divergent and generative thinking frames with convergent ones (see also Blauth, Mauer, & Brettel, 2014; Fernández-Pérez, García-Morales, & Pullés, 2016). This suggests that in evaluating the viability of an novel idea to turn into market success, those individuals who more closely reason about an opportunity according to its immediate merit, seeking to converge quickly at a decision, will overlook a good opportunity and thus inadvertently make less accurate decisions (see Basadur, Runco, & Veaga, 2000; Runco & Smith, 1992).

In sum, creative individuals might therefore be more accurate in forecasting the future potential of novel ideas that are within their domain of expertise (Haynie et al., 2009; Juliusson et al., 2005). Creative individuals may be more likely to accept novel product concepts because they should be able to generate more vivid simulations and representations of the future situations (Peters & Büchel, 2009) in which the product concept exists and then become motivated to pursue these, if considered viable. These

claims lead to the question whether creative people are more likely to accept novel concepts than less creative individuals. We therefore advance the following hypothesis:

H1) More creative individuals are more likely to accept novel product concepts compared to less creative individuals.

Abductive reasoning and creativity

The role of creativity and creative cognition in solving problems or finding novel ideas that break with known patterns has long been discussed in design research (for an overview see Taura & Nagai, 2017). The cognitive strategy in creative cognition of connecting previously unrelated ideas across domains is similar to the process of inventing explanations to surprising observations in abductive reasoning. Abductive reasoning is characterized by the introduction of hypotheses and theories to explain a given result (Peirce, 1932). Abductive reasoning, in contrast to deductive and inductive logic, proposes the most parsimonious explanation for observations (Peirce, 1932), an explanation that may be neither scientifically nor logically true, thus connecting the realms of 'what is' and 'what might be' (Kroll & Koskela, 2014). Two different types of abduction are differentiated: explanatory abduction and innovative (or creative) abduction (Dorst, 2011). The first synthesizes complex, contradictory or incomplete information to determine a likely cause of an effect (see also Kolko, 2010). The latter predefines unknown variables to explain how it will affect a given parameter. This means that abductive reasoning is involved in expanding existing beliefs by seeking new rules and relationships, which is at the heart of creativity. Due to this congruence, we expect abductive reasoning to correlate with the level of creativity. It is likely that creative people exhibit higher levels of abductive reasoning. We propose that:

H2) More creative individuals exhibit more abductive reasoning compared to less creative individuals.

Scholars in the field of design have promoted abductive reasoning, considered the kernel of design thinking (Dorst, 2011; Roozenburg, 1993), to support the selection of novel product concepts (Dong et al., 2015). Abductive reasoning in this situation consists of the formation of a hypothesis about the causes of a desired, but not yet existent, outcome when both (a) the context under which the outcome is likely to occur and (b) the means, i.e., the product or service that can produce the outcome, are not known yet (Dorst, 2011). Individuals then have to invent hypotheses about the causes of the outcome, including the creation of appendant rules and criteria that would plausibly explain the occurrence of the desired result. Decision makers would mentally construe a scenario in which a novel product concept could be a successful innovation and then try to generate an explanation for the outcome (Kroll & Koskela, 2014). This balancing act has similarly been described by Crilly (2018). Moreover, research has shown that committees tasked with selecting concepts for innovative products for funding performed significantly better (i.e., they made more accurate decisions) when manipulated into applying abductive reasoning within their selection processes (Dong et al., 2015; Mounarath et al., 2011), as already briefly discussed previously. More specifically, the number of Type-1 errors (i.e., not investing in ideas that have potential) was found to decrease significantly while there was no significant increase in Type-2 errors (i.e., investing in ideas that have very little potential). In other words, a larger number of novel product propositions carrying actual market potential were chosen. Extending from these findings, two hypotheses are formulated for individual concept selection contexts:

H3) The likelihood of acceptance of a novel product concept for further development increases with the degree of abductive reasoning applied by an individual.

H4) A higher degree of abductive reasoning applied by an individual tasked with selecting novel concept for further development increases the decision accuracy.

Study

To test the formulated hypotheses, we used a combined qualitative and quantitative approach in investigating individuals' selections of novel product concepts that could be turned into innovations. We conducted an experiment comprising a creativity test and subsequent individual selections of real-life innovation concepts sourced from popular crowdfunding portals.

Participants

We recruited 50 participants (35 males, 15 females) from Dutch universities via email. Each participant was asked to make 5 concept selection decisions, amounting to a total of 250 individual decisions. On average, the participants were 24.5 years old (SD = 3.78) with a maximum age of 39 and a minimum of 19. Participants' educational backgrounds comprise design, engineering, business, and science. All of them have attained a high school degree and subsequent tertiary education ranging from ongoing bachelor's degrees to master's and PhD degrees. We chose this sample as most crowdfunding campaigns attract funders under the age of 35.[1] The selected participants hence represent a relevant demographic for the evaluation of the proposed projects. All participants participated on a voluntary basis and were not compensated.

[1] https://www.startups.com/library/expert-advice/key-crowdfunding-statistics

Data acquisition

The task was administered on Qualtrics. Subjects took between 30 and 45 minutes to complete the task. Five different parts had to be completed: (1) complete an Alternative Uses Test, (2) read the project briefs, (3) score familiarity/prior knowledge with the product concepts, (4) make investment decisions, and (5) answer demographic questions, see Figure 1. First, the participants completed the Alternative Uses Test (AUT), which we would later use to evaluate their level of creativity. The AUT assesses cognitive processes closely related to the cognitive processes of analogy, association, and combination (Welling, 2007). The test consisted of two questions granting participants two minutes each time to generate as many alternative uses for two objects, a brick and a jar, as possible (compare Guilford & Hoepfner, 1971). Then, five briefs of the novel product concepts (see Figure 2 for an example) were presented to all participants in random order. After reading all briefs, participants were asked to self-rate their familiarity/prior knowledge with (1) the proposed use case for each product concept (i.e., the suggested utilization of the proposed product by the user) and (2) the familiarity with the technology used/applied in each of the product concepts on a 5-point Likert-scale. Familiarity with a topic is akin to prior knowledge in this area and has been used in prior studies to assess prior knowledge (see e.g., Rao & Monroe, 1988). Familiarity with the use case and the technology were selected as measures as both have been shown to be relevant for product evaluation as well as opportunity recognition (compare Rao & Monroe, 1988; Shane, 2000). Subsequently, participants would view the project briefs again in a randomized order and asked to make their concept selection decisions. It is vital for participants to read all briefs before making any decisions, as the first project brief viewed might otherwise trigger an anchoring bias (compare Tversky & Kahneman, 1974). All decisions had to be made individually,

participants had no knowledge of one another, and were asked to do no research (online or other) on the novel product concepts presented.

Before entering their go/no-go decision for each novel product concept, participants were asked to *'list up to 10 possible extensions of this project that could create new, viable follow-on business opportunities in the next 2-3 years*'. This intervention serves to manipulate participants to imagine future versions of the product concept and stimulate their creativity. The task is more directed than a purely divergent thinking exercise as the hypothesized extensions need to be feasible within the given time span (i.e., '2-3 years') and generate viable commercial value. After generating the extensions, the participants provided a simple YES/NO decision if they *'would fund this project*'. Finally, participants were asked to *'give two to five reasons for their decision*'. Both the project extensions and reasons provided to explain the investment decisions are later used to analyze the level of abductive reasoning applied to the decision (see below).

Figure 1 about here

Project selection and brief generation

The projects presented were derived from products pitched on the popular crowdfunding platforms Kickstarter and Indiegogo. The success or failure of the crowdfunding campaign was used as our dependent variable to assess accuracy of the decisions made in our experiment. Using the success of the respective crowdfunding campaigns as the prediction for their actual success or failure in a real market is supported by research by Kornish and Ulrich (2014) and Girotra, Terwiesch, and Ulrich (2010). Their studies showed a direct correlation between the success of new products

introduced to the market and the initial reception (i.e., the actual financial backing) of the raw ideas for these products by a large user group. Finally, making decisions on the original funding pitch of projects on the crowdfunding websites is closer to the decision-making situation relevant to this research, i.e., filtering early-stage innovation ideas that require funding to be fully developed into concrete market offerings.

Successful projects selected had to have reached at least 200% of their initial funding goal in the crowdfunding campaign, whereas unsuccessful ones needed to remain below 50% of the targeted sum. The projects chosen were all advertised for the same duration on the websites (6 weeks) and requested a similar funding around US$50,000 (with a variance of US$15,000 either way). All projects featured ideas for novel consumer products with extendable features that combined hardware and software parts in the field of electronics or Internet of Things (IoT) through a smartphone connection. The projects chosen for the study and the amount of money raised over or under (negative) target were:

- A wristband that can be programmed via a smartphone app to follow certain behaviors and administer pre-programmed rewards or punishments accordingly to help users change habits. (successful, exceeded the target by US$198,002);
- A smartphone case with an inbuilt electronic writing board for notes. (unsuccessful, remained below target by US$-41,873);
- An earthquake and tsunami alert system including a smartphone app that allows the user to monitor the respective natural phenomenon (unsuccessful, remained below target by US$-34,521);
- A wirelessly operated bicycle tail lamp including direction indicators and a brake light (unsuccessful, remained below target by US$-38,197);

- A portable electronic musical instrument that can play sounds of over 50 different instruments (successful, exceeded the target by US$182,576).

The product concepts were turned into consistently structured and concise briefs following strict rules to avoid systemic errors from a potential framing effect; thus, all briefs were constructed in the same manner:

- Start: Two sentences describing the central function of the proposed product, i.e., *what is it for*?
- Main part: Two to four sentences about how the product fulfils the intended purpose, i.e., *how does it work*?
- End: Two sentences describing the structure, its appearance, and relevant technical specifications, i.e., *what is it made of and what does it look like*?

What is more, the structures of the sentences used in all parts were standardized as much as possible following inspirations by Kozminsky, Kintsch, and Bourne (1981) to facilitate homogeneity in information extraction among participants and avoid text-related framing biases. For instance, the main function of a product concept would always be described using the following structure in the briefs: 'The project proposes (insert what it is) to (insert what its intended purpose is)'. Similarly, following suggestions by Goldschmidt and Sever (2011), visuals were generated as three to five picture storyboards in the same drawing style by a professional illustrator to avoid bias from more stimulating visuals (compare Liang, Chang, & Liang, 2019). Put together, the briefs gave a neutral and concise, yet comprehensive, picture of the essence of each product concept. Intelligibility of the briefs was pilot-tested with ten subjects from a similar population to that of the main study and improved based upon their feedback. An example of a project brief is provided in Figure 2.

Figure 2 about here

Data Analysis, Coding Procedure and Measures used

Assessment of creativity

In order to measure the creativity of the participants, we adopted three alternate scoring systems, namely *Yamamoto sum-scoring* (Yamamoto, 1964), *ideational sets* (Runco & Mraz, 1992), and *weighted fluency* (Runco, Okuda, & Thurston, 1987). By integrating them, we aim to reduce the limitations of the individual scoring systems (cf. Runco & Mraz, 1992; Runco et al., 1987). Common across the three scoring systems is that the creativity score is calculated based on (1) the originality (or novelty) of the ideational output, (2) the flexibility (i.e., the number different categories or themes covered by the ideas, and (3) the fluency (i.e., total number of ideas). The *weighted fluency* method addresses the concern that a higher fluency increases the creativity score over proportionally, independent of whether the idea is original. As the originality and the flexibility are more important in assessing an individual's level of creativity (Runco et al., 1987) we accounted for this by weighting the fluency score by 0.5. The *ideational sets* method suggests evaluating the total ideational output of an individual instead of single ideas. Because of limited time given to complete the AUT, individuals who produced more detailed ideas had less time to produce more ideas (fluency). We address this concern by accounting for the elaboration (detail) of the idea (weighted by 0.33). The formula was used to calculate the creativity score:

$$\sum Originality_i + \sum Flexibility_i + \frac{\sum Fluency_i}{2} + \frac{\sum Elaboration_i}{3}$$

where *i* is the ideational output on an individual. As an example, an individual created a total of 15 ideas of which 6 were deemed original. The 15 ideas covered 5 different categories and 1 idea was more elaborated. The score would be 18.83 (calculation: 6 + 5 + 15/2 + 1/3). On average, individuals generated 11 ideas falling into six different categories. Of the 11 ideas, two were deemed original and one was further elaborated. The median creativity score of our sample is 15 (mean 14.70, SD 6.89). Individuals with a creativity score above the mean plus half a standard deviation were deemed creative, the remaining ones where categorized as less creative. As a robustness check, we calculated the creativity score adapting the weighted-fluency score by Runco et al. (1987). The grouping into highly and less creative individuals remains consistent. For the analysis, we use the creativity score based upon the Yamamoto sum-scoring as described above. Of our 50 participants, 32 fall into the low creativity category and 18 into the high creativity category. Since each participant was shown five product concepts, there are 160 decisions from low creativity and 90 decisions from high creativity participants.

Coding instances of abductive reasoning

To assess the level of abductive reasoning observed in each participant as they generated extensions to the product concepts and justified their investment decisions, we used a qualitative, semantic analysis and inductive, iterative coding (following established work (Miles & Huberman, 1984)). First, all reasons and extensions provided by participants were separated into single ideas, i.e., forward-thinking hypotheses about the novel product idea. Based on an individual screening of the extensions (ideas) provided by the participants, the two main researchers conducting the study created a first set of codes for all extensions (see below). Coded extensions were subsequently reviewed by two additional experienced researchers in the field who were not involved

in conducting the experiment prior. Researchers did not know whether the reasons came from high or low creativity individuals or high or low familiarity individuals. The codes were subsequently compared. All inconsistencies between the codes were discussed between the researchers until consensus was reached. The following four codes were generated to identify the existence or lack of abductive reasoning found in the provided project extensions:

- No abductive reasoning: No reasons or extensions suggested or only inconsequential changes proposed, such as simple accessories or color options.
- Codes for instances of abductive reasoning:
    - Explanation or extension proposes changes of form, manner of behavior, or mode of user interaction of the product. (code A1)
    - Explanation or extension proposes a new purpose or the basis for a new type of product that would be in the same product category, addressing similar needs and competing for the same customers. (code A2)
    - Explanation or extension proposes a different kind of product concept altogether and possibly a new product category and/or market addressing new needs and new customers. (code A3)

Examples of abductive extensions provided by participants are observed in the following statements from the bicycle taillight product concept. As an example of change in the form, one participant wrote, '*Integrating the front light with the control element to indicate direction*' (code A1). As a possible extension, another participant wrote, '*Add GPS tracker pad in case [it is] stolen*'. Here, the bicycle taillight is complemented with a new purpose (in the same product category, i.e., bicycles), namely to allow tracking and potentially retrieving the bike in case it is stolen. This is scored as

satisfying the second criterion as stated previously (code A2). Another participant wrote, '*In the event of e-bikes, you can let this device monitor for nearby cyclists in front of you and adjust its speed based on this, kind of like cruise control with automatic distance monitoring*.' In this example both a new purpose and a new product category are introduced (i.e., the light suddenly turns into a biking assistance device; code A3).

The abductive reasons provided by participants to explain their respective decisions were analyzed in the same manner as described above and the same set of codes was found to be suitable. Examples of abductive explanations for the wristband project read like the following. One participant explained that a *'Better solution would be as software/app for already-existing hardware'*. Here, the reason is the hypothesis of a different type of product appearing on the market, which might be superior (code A1). Another participant wrote: *'It could reduce the amount of people who don't take their medicine in time, which could reduce [health] costs'*. The person is suggesting a new context of use and subsequent value proposition (i.e., reduce health costs) that could explain the product concept's chances for market success. Yet, the product itself does not change significantly and still targets the same users (code A2). The following statement is an example of a reason not to accept the Smartphone Case project: *'However, the technology-knowledge attained from this project might be useful for other products (laptops, computers, touch-screens) (write on a handheld note[book], press a button and it is saved. When it has a connection with internet, it sends it to your home router which will have the notes automatically pop up on the connected devices (phone, computer or even fridges these days) until you remove them.'* Here, the participant proposes another product concept that might have a stronger value proposition (code A3).

Assessment of prior knowledge

As discussed above, we operationalize prior knowledge as (1) familiarity with the use case (how well the participant knows the situation in which (or circumstances under which) the product would be used), and (2) familiarity with the technology used. For each product concept, participants self-rated both types of familiarity on a 5-point Likert-scale from 1 (low familiarity) to 5 (high familiarity). The two types of familiarity contribute to the overall level of prior knowledge; however, they may not correlate with each other. Therefore, for further analysis, we control for the prior knowledge variables: (1) USE CASE (familiarity with the use case) and (2) TECHNOLOGY (familiarity with the technology).

Analysis and Results

Out of the 250 total decisions, 133 decisions were to reject product concepts and 117 were to accept product concepts.[2] Forty-five percent of the participants accepted three or more concepts, and 37 percent accepted exactly two, though not necessarily the correct 2 concepts. Seventeen percent accepted only one or none of product concepts. Based upon this profile of decisions, the participants exhibited a tendency to reject product concepts. Therefore, if we find evidence that creativity increases the likelihood of accepting product concepts, the finding will be stronger given that this population exhibits a predisposition to reject new product concepts.

[2] Similar acceptance/rejection rates were indeed found in research by Berg (2016), Dong et al. (2015) and Mounarath et al. (2011) where (groups of) participants had to make similar decisions on a set of given innovation opportunities.

We first calculated Pearson's correlation coefficients between the participants' creativity score and the number of explanatory (REASONS) and innovative (EXTENSIONS) abductions for all participants, shown in Table 1. There is initial evidence supporting H1: more creative individuals are more likely to accept (ACCEPTANCE) the new product concepts, though the effect size is small (Pearson's r = .129). There is partial support for H2, as there is a statistically significant relation between the number of extensions (EXTENSIONS) and the creativity score (CREATIVITY) with a small effect size (r = .176), but no significant relation between the number of explanatory abductions (REASONS) and creativity score (CREATIVITY). More creative individuals are likely to generate more extensions to the presented product concepts. Furthermore, explanatory and innovative abductions are positively correlated at the 10% level (p = *.0593*).

Table 1 about here

Since decisions are nested within each participant, following recommendations from established literature (e.g. Enders & Tofighi, 2007), we calculated a hierarchical linear model (HLM) in which each participant's decisions (level-1) are nested within participants (level-2). The HLM was calculated utilizing the *lme4* (1.1-14) package in R (3.4.2) for both ACCEPTANCE and ACCURACY. The first HLM was conducted to test the likelihood to accept a product concept (ACCEPTANCE, level-1 outcome variable) whereas the second HLM was conducted to test the accuracy of a decision (ACCURACY, level-1 outcome variable). Both models were based on the following predictors: REASONS and EXTENSIONS. CREATIVITY is dropped from the regression since it correlates with EXTENSIONS (multicollinearity) and is the same

value per participant per decision. In addition, we controlled for familiarity with the use case (USE) and technology (TECH). The equation of the model for ACCEPTANCE is as follows:

Level-1 Model

$\text{Prob}(\text{ACCEPTANCE}_{mj}=1|\psi_j) = \varphi_{mj}$

$\log[\varphi_{mj}/(1 - \varphi_{mj})] = \eta_{mj}$

$\eta_{mj} = \psi_{0j} + \psi_{1j}*(\text{REASONS}_{mj}) + \psi_{2j}*(\text{EXTENSIONS}_{mj}) + \psi_{3j}*(\text{USE}_{mj}) + \psi_{4j}*(\text{TECH}_{mj})$

Level-2 Model

$\psi_{0j} = \gamma_{00} + u_{0j}$

$\psi_{1j} = \gamma_{10} + u_{1j}$

$\psi_{2j} = \gamma_{20} + u_{2j}$

$\psi_{3j} = \gamma_{30} + u_{3j}$

$\psi_{4j} = \gamma_{40} + u_{3j}$

Level-1 variance = $\sigma 2_{\varepsilon}/[\varphi_{mj}(1-\varphi_{mj})]$

According to an ANOVA analysis, the HLM model is significantly better than the null model in which the only predictor is the participants themselves (p = .001). The ACCEPTANCE model shown in Table 2 shows that the regression coefficient related to both REASONS and EXTENSIONS is positive and statistically significant (with a root-mean-square standardized effect sizes of ψ_1 = .397, z = 2.44, with p = .01; and ψ_2 = .197, z = 2.53, p = .01), indicating that the degree of abductive reasoning increases the likelihood of accepting projects. Since EXTENSIONS positively correlates with CREATIVITY, we can conclude that H1 is supported and thus creative individuals are indeed more likely to accept product concepts. Neither familiarity with the use case (USE) nor technology (TECH) affected the likelihood of accepting a product concept.

Table 2 about here

A similar model was run for ACCURACY, as shown in Table 3. Again, using an ANOVA analysis, the model is superior to the null model (p = .019). The number of abductive reasons (REASONS) significantly explains the decision accuracy (ψ_1 = .416 with z = 2.59, p = .01), while the number of abductive extensions (EXTENSIONS) is significant only at the 10% level. Neither familiarity with the use case (USE) nor technology (TECH) influence decision accuracy. There is thus strong support for H3: a high level of abductive reasoning increases the likelihood of accepting a product concept. There is partial support for H4: a high level of abductive reasoning increases the decision accuracy but only when the abductive reasoning is in the form of explanatory abductions (i.e., in providing abductive reasons for a decision) rather than innovative abductions (i.e., the abductive extensions made prior to the decision point).

Table 3 about here

It should be noted that in financial decision making, small variances can have a significant impact that may very well determine success or failure of entire companies (see Lovallo & Sibony, 2010). Equally, when individuals and companies take decisions to invest or not invest in an idea, they tend to follow through on the decision. To determine the effect of creativity on the actual wins or losses that participants (would have) have incurred, we calculated the fictive financial returns achieved on average per project by the low and high creativity groups. This means, if a participant decides to invest in a product and the product is a winning one, then the return is the total amount of funds raised for the project minus the requested investment. If a participant decides to

invest in a product that fails to achieve its funding goal, the loss is calculated as the total requested investment. We found that the high creativity group had an actual mean positive return of US$152,954 compared to US$75,159 for the low creativity group. Furthermore, the high creativity group showed a 22.2% higher decision accuracy compared to the latter. These are conspicuous differences with significant implications for the scholarship on creative cognition in decision making for choices under uncertainty and risk as well as for the way *how* companies should approach and make such decisions in the early stages of their innovation processes, in order to facilitate portfolio performance.

Discussion

The insights obtained in the presented experimental study strongly support hypotheses H1 and H2. We found that more creative participants are more likely to accept novel product concepts. The more product extensions participants generate – correlating with an individual's creativity – the more likely they are to accept novel product concepts for further development. Equally, the more explanatory abductions participants exhibited, the more likely participants are to accept ideas and also to make correct decisions in accepting (and also rejecting bad) projects. Finally, there is no effect of prior knowledge in the form of familiarity with the use case or technology on the propensity to accept novel product concepts or accuracy of decision-making.

With reference to extant theory, the novel ideas presented to the subjects tasked them with the daunting complexity of making choices on innovation opportunities for which the actual outcomes are extreme uncertainty, i.e., information is rather incomplete, ideas may not follow established market trends and thus not lend themselves to typical metrics-based evaluations, and, finally, the time at which the innovation is ultimately going to market is still unknown. As such, the experiment

replicates scenarios of decision-making under extreme uncertainty as frequently discussed in theory of choice (Kahneman, Slovic, Slovic, & Tversky, 1982; Lipshitz & Strauss, 1997; Shane, 2009). The findings suggest that the way one thinks and reasons about an innovative idea might be a determinant of how effective one's decision making will be. More creative participants showed an increased accuracy in choosing from similarly attractive but uncertain alternatives in the conducted experiment. Creative thought in decision making entails engaging in pre-factual thought and (re)framing the potential innovation as a way to obtain added utility at a later point in time, and potentially in a different from what was proposed (Epstude, Scholl, & Roese, 2016). We conjecture that more creative individuals used the extensions they created as a mental hypothesis of how the given innovation ideas *could* create significant future value – in other words, the extension became a hypothesis of what the idea could turn into and this they could then mentally explore further, evaluate, and eventually select the most plausible ones. In essence, the hypothesis creates a need for the subjects to mentally test the effect of the extensions since downstream effects are not yet known (Christensen & Schunn, 2009). This may have stimulated the more creative individuals to mentally test, expand, test again, etc. until they were (not) able to identify a sensible way to market success (compare Ball & Christensen, 2009; Basadur et al., 2000; Nguyen & Zeng, 2017; Runco & Smith, 1992), which is an effective way of reducing the inherent uncertainty. This, at its kernel, is why we observe an increase in accuracy in this test group.[3] Conversely, less creative participants likely applied less creative thinking and

[3] It is important to note that the hypothesis embodies no necessary belief that the new feature or monetization strategy will (not) actually be developed, but that if it *were* developed, then a causal effect will occur.

used more established rules or metrics-based decision making. This has been suggested to tightly couple a person's minds to their past and present experiences, preventing them from exploring ways an innovation opportunity would be successful. As a consequence, the less creative participants in our experiment ended up rejecting many 'good' ideas.

Our study also contributes to the role of excitement in decision making. Thinking about options and opportunities can motivate people to become excited and thus create a higher propensity to accept ideas for development, which is supported by extent research (Dasgupta & Maskin, 2005). As highly creative participants generated more extensions (thus thought more about options and opportunities) we would expect them to become more excited and accept more products for further development. The finding that highly creative participants selected more novel and more 'successful' product concepts for further development suggests that, while motivation may play a role in decision making, it is not the sole mechanism underlying the relation between creativity and decision making. How individuals reason through the options and opportunities is hence vital for the decision to accept projects for further development.

Our findings have important implications as to *how* and *by whom* strategic decisions on new product concepts should be made within an organization in early stages of screening ideas proposed for adoption and development by an organization. More creative individuals tended to select more successful projects for funding and generally outperformed the less creative participants in terms of investment return. These findings suggest that by selecting individuals with strong creative capabilities (using established creativity tests) to perform the filtering of early-stage innovation concepts within an organization, a company may be able to boost their growth through innovation substantially.

Lastly, our analysis showed no correlation between prior knowledge (control variable) and project acceptance nor between prior knowledge and the accuracy of the decision to accept or reject an innovation idea. Studies on entrepreneurship find that prior knowledge influences the way an individual searches for (Fiet, 1996) and recognizes potentially profitable opportunities (Shane, 2000). Since none of the individuals reported having no knowledge in the domain, the results should not be construed to suggest that domain knowledge is unnecessary. Rather, the results show that decision-makers should be encouraged to think expansively on future potential. During the assessment, proponents and opponents should be asked to propose extensions and to explain the value drivers behind those extensions. In sum, our results suggest that, ceteris paribus, an individual's creativity correlates positively with the likelihood of accepting novel product concepts and the accuracy of go/no-go decisions.

Limitations and Future Research

Limitations to the conducted study may arise from our assessment of creativity using the divergent thinking test, which only assesses verbal performance. Some scholars argue that creativity is a domain-specific and subjective judgement of novelty which is likely to change over time (Baer, 1998; Ford & Gioia, 2000). This suggests that we may obtain different creativity results with a non-verbal test. Other research, however, gives reason to believe that domain-specificity is not of relevance (Plucker & Beghetto, 2004). Therefore, the selected method is considered suitable for this research. Our analysis is based on the Yamamoto sum-scoring to asses an individual's level of creativity. A different scoring method may have led to different results. We applied three methods to minimize this potential effect. Furthermore, the grouping into highly-creative and less creative individuals is consistent with all three methods, which mitigates this concern.

Limitations may further come from the reasoning provided by the participants. Since all participants were asked to first generate potentials extensions for the projects and then make their funding decisions, the level of abductive reasoning during the decision-making might actually be higher than measured. The reason is that some participants might have used the future extensions that they listed earlier as support for their investment decisions but did not explicate the underlying convictions/thoughts while providing the reasons for each of their decisions afterwards. However, the data provided in the section where reasons had to be stated was very rich, which increases confidence that the data represents the underlying reasoning processes of the participants sufficiently well.

In this study, we focused on the level of an individual's creativity on the selection of novel product concepts for further development. While we do control for an individual's level of prior knowledge, we do not examine the influence of other personal factors on making such decisions. Future research may want to explore the effect of other personal factors, such as the level of uncertainty and the experience in making such decisions, on the likelihood to accept novel product concepts and on the accuracy of the decision. It might also be interesting to investigate the importance of creativity on the selection of novel product concepts relative to other factors. Furthermore, future research may investigate the effect of creativity on the selection of novel product concepts in a group setting. Is it that many creatives accept more concepts and those that have a larger potential of becoming a successful innovation? Or are more heterogonous groups (highly creative individuals and less creative individuals) better at making such decisions?

Conclusions

In this study, we investigated differences between the propensity of participants tasked

with selecting novel product concepts for further development into potentially successful innovation in the market based upon the participant's level of creativity. In summary, more creative individuals were more likely to accept novel product concepts. Second, the findings show that abductive reasoning is one cognitive strategy that can improve the propensity to accept novel product concepts while at the same time positively influencing their correct selection. If companies are concerned that creative people might have the tendency to accept *any* novel product concept, our research should allay those concerns. Conversely, if companies find that their decision makers are too risk averse, and tend to reject all new ideas for products, they may improve their outcomes by having more creative individuals participate in the selection. This research overall provides support to Herbert Simon's famous quote, 'Innovation has a lot to do with your ability to recognize surprising and unusual phenomena'. Priming people to apply creative thinking in such a way that they can improve their ability to make decisions about novel product and service opportunities should serve as an agenda for future research in creativity and innovation management, to complement the long line of research on priming individuals for more creative ideation.

References

Assink, M. (2006). Inhibitors of disruptive innovation capability: a conceptual model. *European Journal of Innovation Management, 9*(2), 215-233. doi: doi:10.1108/14601060610663587

Baer, J. (1998). The Case for Domain Specificity of Creativity. *Creativity Research Journal, 11*(2), 173-177. doi: 10.1207/s15326934crj1102_7

Ball, L. J., & Christensen, B. T. (2009). Analogical reasoning and mental simulation in design: two strategies linked to uncertainty resolution. *Design Studies*, *30*(2), 169–186. doi: 10.1016/j.destud.2008.12.005

Basadur, M., Runco, M. A., & Veaga, L. A. (2000). Understanding how creative thinking skills, attitudes and behaviors work together: A causal process model. *The Journal of Creative Behavior*, *34*(2), 77-100.

Berg, J. M. (2016). Balancing on the creative highwire: Forecasting the success of novel ideas in organizations. *Administrative Science Quarterly*, *61*(3), 433-468.

Blauth, M., Mauer, R., & Brettel, M. (2014). Fostering creativity in new product development through entrepreneurial decision making. *Creativity and Innovation Management, 23*(4), 495-509.

Christensen, B. T., & Schunn, C. D. (2009). The role and impact of mental simulation in design. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, 23*(3), 327-344.

Cooper, R. G., & Kleinschmidt, E. J. (1986). An Investigation into the New Product Process: Steps, Deficiencies, and Impact. *Journal of Product Innovation Management, 3*(2), 71-85. doi: 10.1111/1540-5885.320071

Crilly, N. (2018). 'Fixation'and 'the pivot': balancing persistence with flexibility in design and entrepreneurship. *International Journal of Design Creativity and Innovation, 6*(1-2), 52-65.

Dasgupta, P., & Maskin, E. (2005). Uncertainty and hyperbolic discounting. *American Economic Review, 95*(4), 1290-1299.

Delas, A., Maranzana, N., Mantelet, F., & Buisine, S. (2015). Encouraging innovation activity: in the specific context of small- and medium-sized retailers. *International Journal of Design Creativity and Innovation, 3*(3-4), 211-238. doi: 10.1080/21650349.2014.975158

Dew, N., Read, S., Sarasvathy, S. D., & Wiltbank, R. (2009). Effectual versus predictive logics in entrepreneurial decision-making: Differences between experts and novices. *Journal of Business Venturing, 24*(4), 287-309.

Diebold, F. X., Doherty, N. A., & Herring, R. J. (2010). *The known, the unknown, and the unknowable in financial risk management: measurement and theory advancing practice*: Princeton University Press.

Dong, A., Lovallo, D., & Mounarath, R. (2015). The effect of abductive reasoning on concept selection decisions. *Design studies, 37*, 37-58.

Dorst, K. (2011). The core of 'design thinking'and its application. *Design studies, 32*(6), 521-532.

Eling, K., Langerak, F., & Griffin, A. (2015). The performance effects of combining rationality and intuition in making early new product idea evaluation decisions. *Creativity and Innovation Management, 24*(3), 464-477.

Enders, C. K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: a new look at an old issue. *Psychological methods, 12*(2), 121.

Epstude, K., Scholl, A., & Roese, N. J. (2016). Prefactual thoughts: Mental simulations about what might happen. *Review of General Psychology, 20*(1), 48-56.

Fernández-Pérez, V., García-Morales, V. J., & Pullés, D. C. (2016). Entrepreneurial decision-making, external social networks and strategic flexibility: The role of CEOs' cognition. *European Management Journal, 34*(3), 296-309.

Fiet, J. O. (1996). The informational basis of entrepreneurial discovery. *Small business economics, 8*(6), 419-430.

Finke, R. A., Ward, T. B., & Smith, S. M. (1992). Creative cognition: Theory, research, and applications.

Ford, C. M., & Gioia, D. A. (2000). Factors Influencing Creativity in the Domain of Managerial Decision Making. *Journal of Management, 26*(4), 705-732. doi: doi:10.1177/014920630002600406

Gavetti, G., & Levinthal, D. (2000). Looking Forward and Looking Backward: Cognitive and Experiential Search. *Administrative Science Quarterly, 45*(1), 113–137. doi: 10.2307/2666981

Girotra, K., Terwiesch, C., & Ulrich, K. T. (2010). Idea generation and the quality of the best idea. *Management science, 56*(4), 591-605.
Goldschmidt, G., & Sever, A. L. (2011). Inspiring design ideas with texts. *Design studies, 32*(2), 139-155.
Gonzalez, M. E. Q., & Haselager, W. P. F. G. (2005). Creativity: Surprise and abductive reasoning. *Semiotica, 2005*(153-1/4), 325-342.
Guilford, J. P., & Hoepfner, R. (1971). *The analysis of intelligence*: McGraw-Hill Companies.
Hansen, D. J., Lumpkin, G. T., & Hills, G. E. (2011). A multidimensional examination of a creativity-based opportunity recognition model. *International Journal of Entrepreneurial Behavior & Research*.
Haynie, J. M., Shepherd, D. A., & McMullen, J. S. (2009). An opportunity for me? The role of resources in opportunity evaluation decisions. *Journal of Management Studies, 46*(3), 337-361.
Henderson, R. M., & Clark, K. B. (1990). Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, 9-30.
Huang, L., & Pearce, J. L. (2015). Managing the unknowable: The effectiveness of early-stage investor gut feel in entrepreneurial investment decisions. *Administrative Science Quarterly, 60*(4), 634-670.
Juliusson, E. Á., Karlsson, N., & Gärling, T. (2005). Weighing the past and the future in decision making. *European Journal of Cognitive Psychology, 17*(4), 561-575.
Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.
Kahneman, D., Slovic, S. P., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases*: Cambridge university press.
Kolko, J. (2010). Abductive thinking and sensemaking: The drivers of design synthesis. *Design Issues, 26*(1), 15-28.
Kornish, L. J., & Ulrich, K. T. (2014). The importance of the raw idea in innovation: Testing the sow's ear hypothesis. *Journal of Marketing Research, 51*(1), 14-26.
Kozminsky, E., Kintsch, W., & Bourne, L. E. (1981). Decision making with texts: Information analysis and schema acquisition. *Journal of Experimental Psychology: General, 110*(3), 363.
Kroll, E., & Koskela, L. (2014). On the problem of abduction in design. *Design Computing and Cognition*, 357-376.
Leder, H., & Carbon, C. C. (2005). Dimensions in appreciation of car interior design. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, 19*(5), 603-618.
Lee, J. H., Gu, N., & Ostwald, M. J. (2015). Creativity and parametric design? Comparing designer's cognitive approaches with assessed levels of creativity. *International Journal of Design Creativity and Innovation, 3*(2), 78-94.
Liang, C.-T., Chang, Y., & Liang, C. (2019). How can pictorial representations stimulate the imaginative capacity of experienced multimedia designers? *International Journal of Design Creativity and Innovation, 7*(3), 179-192. doi: 10.1080/21650349.2018.1465477
Lieberman, M. B., & Montgomery, D. B. (1988). First-mover advantages. *Strategic Management Journal, 9*(S1), 41-58.
Lipshitz, R., & Strauss, O. (1997). Coping with uncertainty: A naturalistic decision-making analysis. *Organizational Behavior and Human Decision Processes, 69*(2), 149-163.

Lovallo, D., & Sibony, O. (2010). The case for behavioral strategy. *McKinsey Quarterly, 2*(1), 30-43.
Melcior, J., & Eisenbart, B. (2017). *Radical innovation may need a helping hand.* Proceedings of the 29th Australian Conference on Computer-Human Interaction.
Meyer, M. L., Hershfield, H. E., Waytz, A. G., Mildner, J. N., & Tamir, D. I. (2019). Creative expertise is associated with transcending the here and now. *Journal of Personality and Social Psychology, 116*(4), 483-494. doi: 10.1037/pspa0000148
Miles, M. B., & Huberman, A. M. (1984). Drawing valid meaning from qualitative data: Toward a shared craft. *Educational researcher, 13*(5), 20-30.
Mounarath, R., Lovallo, D., & Dong, A. (2011). *Choosing Innovation: How Reasoning Affects Decision Errors.* DS 68-7: Proceedings of the 18th International Conference on Engineering Design (ICED 11), Impacting Society through Engineering Design, Vol. 7: Human Behaviour in Design, Lyngby/Copenhagen, Denmark, 15.-19.08. 2011.
Narayanan, V. K., Zane, L. J., & Kemmerer, B. (2011). The Cognitive Perspective in Strategy: An Integrative Review. *Journal of Management, 37*(1), 305–351. doi: 10.1177/0149206310383986
Nguyen, T. A., & Zeng, Y. (2017). A theoretical model of design fixation. *International Journal of Design Creativity and Innovation, 5*(3-4), 185-204. doi: 10.1080/21650349.2016.1207566
Peirce, C. S. (1932). Collected writings, 2: Elements of logic. *Cambridge, Mass.: Harvard UP*.
Peters, J., & Büchel, C. (2009). Overlapping and Distinct Neural Systems Code for Subjective Value during Intertemporal and Risky Decision Making. *The Journal of Neuroscience, 29*(50), 15727–15734. doi: 10.1523/jneurosci.3489-09.2009
Plucker, J. A., & Beghetto, R. A. (2004). Why Creativity Is Domain General, Why It Looks Domain Specific, and Why the Distinction Does Not Matter. In R. J. Sternberg, E. L. Grigorenko & J. L. Singer (Eds.), *Creativity: From potential to realization* (pp. 153-167). Washington, DC, US: American Psychological Association.
Rao, A. R., & Monroe, K. B. (1988). The moderating effect of prior knowledge on cue utilization in product evaluations. *Journal of consumer research, 15*(2), 253-264.
Rogers, E. M. (2010). *Diffusion of innovations*: Simon and Schuster.
Roozenburg, N. F. (1993). On the pattern of reasoning in innovative design. *Design studies, 14*(1), 4-18.
Rottenstreich, Y., & Kivetz, R. (2006). On decision making without likelihood judgment. *Organizational Behavior and Human Decision Processes, 101*(1), 74-88.
Runco, M. A., & Mraz, W. (1992). Scoring divergent thinking tests using total ideational output and a creativity index. *Educational and Psychological measurement, 52*(1), 213-221.
Runco, M. A., Okuda, S. M., & Thurston, B. J. (1987). The Psychometric Properties of Four Systems for Scoring Divergent Thinking Tests. *Journal of Psychoeducational Assessment, 5*(2), 149-156. doi: doi:10.1177/073428298700500206
Runco, M. A., & Smith, W. R. (1992). Interpersonal and intrapersonal evaluations of creative ideas. *Personality and Individual differences, 13*(3), 295-302.
Shane, S. (2000). Prior knowledge and the discovery of entrepreneurial opportunities. *Organization science, 11*(4), 448-469.

Shane, S. (2009). Why encouraging more people to become entrepreneurs is bad public policy. *Small business economics, 33*(2), 141-149.

Suddendorf, T. (2010). Episodic memory versus episodic foresight: Similarities and differences. *Wiley Interdisciplinary Reviews: Cognitive Science, 1*(1), 99–107. doi: 10.1002/wcs.23

Taura, T., & Nagai, Y. (2017). Creativity in Innovation Design: the roles of intuition, synthesis, and hypothesis. *International Journal of Design Creativity and Innovation, 5*(3-4), 131-148.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*, 1124-1131.

Welling, H. (2007). Four Mental Operations in Creative Cognition: The Importance of Abstraction. *Creativity Research Journal, 19*(2-3), 163-177. doi: 10.1080/10400410701397214

Yamamoto, K. (1964). Role of creative thinking and intelligence in high school achievement. *Psychological Reports, 14*(3), 783-789.

Tables

	REASONS	EXTENSIONS	ACCEPTANCE	CREATIVITY
REASONS	1	0.12	0.17**	0.02
EXTENSIONS	0.12	1	0.18**	0.18**
ACCEPTANCE	0.17**	0.18**	1	0.13*
ACCURACY	0.15*	-0.10	-0.21**	0.01
CREATIVITY	0.02	0.18**	0.13*	1

* Correlation is significant at a 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Table 1: Pearson's correlation matrix for all participants

Fixed Effects	Coefficient	Std. Error	z-value	p-value
(Intercept)	-1.365	0.442	-3.087	0.002
REASONS	0.396	0.162	2.443	0.014
EXTENSIONS	0.197	0.078	2.529	0.011
USE	0.101	0.122	0.825	0.409
TECH	0.113	0.128	0.878	0.380

Table 2: HLM Results for likelihood of accepting product concept

Fixed Effects	Coefficient	Std. Error	z-value	p-value
(Intercept)	-0.548	0.425	-1.29	0.197
REASONS	0.415	0.160	2.59	0.009
EXTENSIONS	-0.150	0.077	-1.94	0.053
USE	0.171	0.123	1.38	0.165
TECH	-0.039	0.128	-0.31	0.756

Table 3: HLM Results for accuracy of decisions about product concept

Figures

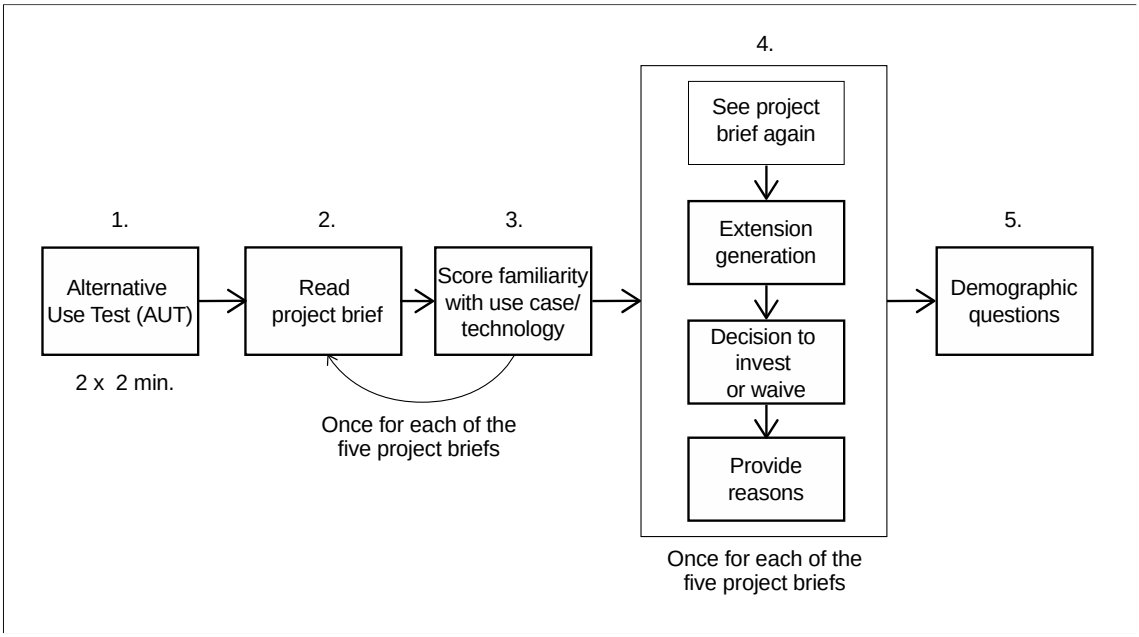

Figure 1: Schematic overview of the study

Project 6: "Personal coach wristband"

This project proposes a wristband that is controlled by a smartphone app and provides users with positive or negative feedback in relation to specified behaviors. It provides feedback to help the users change certain habits, such as exercising more often.
The user defines the specific good or bad behaviors to be addressed and selects the particular punishments or positive feedback associated with them in the app. The app monitors the behavior, by tracking location, movement, phone usage, time spent on different media, etc. and administers the feedback accordingly. Punishments may include vibration of the wristband, loud, annoying sounds, or a mild electric shock. Positive feedback may include gift cards or unlocking pre-defined monetary rewards (pre-paid e.g. by friends) and is intended to maintain motivation and embed new habits.
The app connects to the wristband via Bluetooth 4.0 and uses the phone's integrated sensors, such as GPS, to track behavior. The collected data is analyzed by the app and visualized on the screen for the users to track progress. Using the smartphone, data can be shared with an online community.

Estimated retail price: 249 USD

Illustration

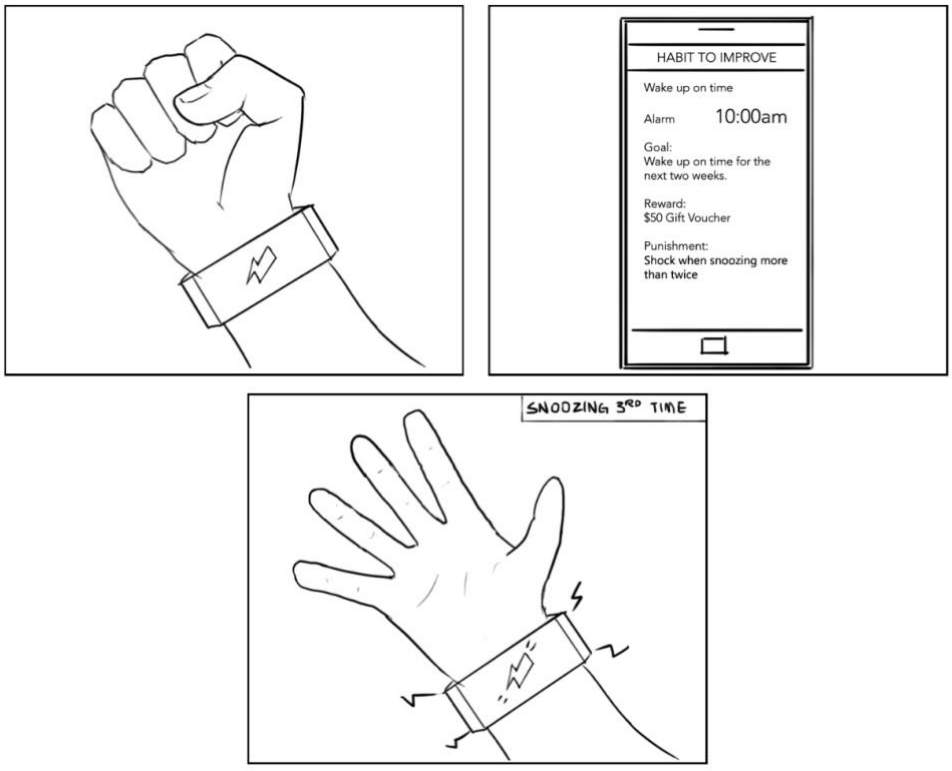

Figure 2: Example of project brief for the wristband project