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DESIGN BRIEFS IN CREATIVITY STUDIES

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Abstract: This paper examines recent experimental studies of early conceptual design identifying a broad diversity of research practices. A high variance is revealed across 75 recent studies from leading design journals on how the design briefs are presented to participants, participants' number and experience, and the time allocated for ideation. These divergent practices may impact the validity of experimental studies. Three indicators are proposed here to assist researchers to prepare design briefs: polysemy, innovation, and communication. An experimental design canvas is presented and illustrated to structure the design of experiments. The paper closes with recommendations to assist in the synthesis of design briefs.

Keywords: *research methods; ideation; brainstorming; design briefs*

1. Introduction

In creativity experiments, design briefs (tasks or problem statements) are used to orient the activity of participants. These types of briefs are open-ended and call for as many original ideas as participants can generate, in contrast to problem-solving briefs (Goel & Pirolli, 1992). Open-ended briefs belong to a more general class of experimental tasks (Fink et al., 2007). Design briefs direct creative activity to transform undesired situations into desired ones. In experimental studies of early conceptual design activity, researchers often create briefs to address research questions related to fixation, design-by-analogy, and ideation methods. Briefs that allow participants to generate many solutions and are not too difficult to solve are recommended (Shah et al., 2000). Whilst the ways in which design briefs are defined may shape the outcomes (Shah et al., 2000), only a few studies focus on the challenges associated with defining the brief (Kumar & Mocko, 2016; Zahner et al., 2010). The instructions given to participants play a key role in experimental studies; their wording needs to be contentiously scrutinised, since even subtle differences can lead to different responses (Lazar et al., 2017). The effects of briefs in the outcomes of these studies has remained largely unaddressed (Goldschmidt & Smolkov, 2006). This represents a methodological issue that may explain the inconsistent outcomes in the literature (Chan et al., 2015).

This paper presents an examination of design briefs from the recent literature that reveals a lack of consensus. After a review of definitions and background studies, three indicators are proposed for the definition of design briefs: polysemy, innovation, and communication. The experimental design

canvas is presented and illustrated to structure the design of experiments based on the characteristics of the design brief defined. The paper closes with recommendations for the synthesis of design briefs.

2. Background

Design problems present incomplete information in start state, end state, and transformation functions, causing extensive structuring before and during the process of solution synthesis (Goel & Pirolli, 1992). Design problems can be seen as creative or routine depending on the mutability of the problem and solution spaces as a result of design activity (Gero, 1990). Taxonomies of design problems have included factors such as degree of innovation involved, degree of complexity of the target outcomes, and degree of tightness of constraints or requirements (Frost, 1994). Creative design is viewed as a constant iteration of analysis, synthesis, and evaluation processes between partially defined problem and solution spaces, i.e., co-evolution of problem and solution (Maher & Poon, 1996).

An analysis of twenty-five studies suggested that participants' ideas can be influenced by the way in which the brief is presented, including the level of abstraction and instructions provided, as well as contextual factors such as task duration and group size (Vasconcelos & Crilly, 2016). For example, design briefs that are framed using more abstract terms may promote the divergence of ideas, whilst more concrete brief definitions may increase convergence but yield solutions that better fit the brief constraints (Zahner et al., 2010). A thorough and systemic analysis of design briefs in the literature is challenging, as often key information is not reported. A recent review of forty-five research articles yielded a similar number of unique design briefs raising the question of how design problems can be differentiated objectively, and revealing the need for methods to assess design briefs in experimental studies (Kumar & Mocko, 2016). In the context of analogical reasoning, general linguistic representations that can be applied across several domains and general forms can be more productive in the creative re-use of design ideas than domain-specific representations (Linsey et al., 2008). With respect to conceptual proximity, a study of textual descriptions of design briefs revealed that an intermediate type of stimulus (not too close, not too distant) is more likely to increase idea fluency, flexibility, and originality (Gonçalves et al., 2013). However, only studies with small sample sizes have reviewed the effects of exposing participants to variations of the problem statement (Wodehouse & Ion, 2012).

Defining a design brief that is representative and appropriate for the research questions has been identified as one of the most elusive challenges of experimental design research (Toh & Miller, 2015). As such, a better understanding of brief synthesis is likely to advance the level of validity in this area and help assess claims of generalizability and transferability (Arrighi et al., 2015). The most suitable levels of prolificacy, abstraction, and other key characteristics could be addressed more explicitly and rigorously in experimental studies of design creativity (Vasconcelos & Crilly, 2016).

3. Analysis of design briefs

A comprehensive collection of design tasks was extracted through an exhaustive search applied to the library databases: ScienceDirect, ProQuest, SCOPUS, JStor, ASME, Taylor&Francis, EBSCOhost, SpringerLink, and Wiley Online. To define the keywords, an iterative process was used of "exploding" and "focusing" terms using a thesaurus and common words from an initial set of hits (35). Alternate keywords as well as tools such as the 'Find Similar' or 'Related Articles' were applied. This process continued until no new papers were found, hence the search conducted can be considered exhaustive. The main keywords used included: ("design problem", "design task", "design brief", "problem statement") and (ideation, "idea generation", brainstorm, creativity). Seventy-five studies are analysed here, comprising the period from 2012 to 2017 in the following design journals: Design Studies (34 papers), Journal of Mechanical Design (14), Artificial Intelligence for Engineering Design, Analysis and Manufacturing (9), International Journal of Technology and Design Education (7), International Journal of Design Creativity and Innovation (6), and Journal of Engineering Design

(5). A total of 92 unique design briefs were identified in the 75 studies analysed, with only six briefs used more than once. These can be classified by domain as: general design (G), such as a paperclip design problem (Viswanathan & Linsey, 2013); building design (B), such as a conceptual design for a commercial building (Yu et al., 2015); device design (D), such as a small-scale device to dry a sliced apple using hot-air blowers (Chua et al., 2014); product design (P), such as toys that aid young children to develop cognitive abilities (Mohedas et al., 2015); and service design (S), such as to reduce overdue accounts/unpaid credits (Moreno et al., 2014). Finally, four studies focused on ongoing design projects (O) that designers were working on (Cash et al., 2015). The main difference between D and P types is the explicit identification of a target user in the brief.

Based on the operating variables identified by (Shah et al., 2000), these studies were classified by their research question(s), design task name, design task description, justification for design task selection (when present), number and type of participants in the study, time allocated to the ideation activity, type or format of output asked from participants, and evaluation metrics of the output. We focus here on orientation and synthesis rationale characteristics. Orientation differentiates between "problem-oriented" briefs that describe an undesired situation, such as "generate as many ideas as possible to eliminate the need to have multiple bikes as people grow up" (Vasconcelos et al., 2017), and "solution-oriented" briefs where a target solution is specified, such as "manually making the burritos for these many people is laborious, thus the goal is to design a burrito-making device" (Worinkeng et al., 2015). Solution-oriented briefs are more common (73%) than problem-oriented briefs (27%) in the studies analysed. Synthesis of the design brief distinguishes between studies with or without "explicit justification". Studies with explicit justification include a rationale for the design brief, such as (Daly et al., 2016) who reviewed research experiments and engineering curricula, and chose a familiar context for participants, without requiring in-depth domain knowledge, and novel enough to prevent solutions to be known. About half of the studies included design briefs without any explicit rationale for their selection and framing. Table 1 shows a sample of 15 briefs indicating their design domain (Domain), a short description (Brief), whether their orientation (Orient) frames a problem (Prob) or a solution (Sol), whether the rationale for their selection (Rat) is explicit (E) or not (N), and the source study.

Table 1. Sample design briefs used in the studies, 2012-2017.

Domain	Brief	Orient	Rat	Reference
G	A 21st century birthday celebration	Prob	N	(Cardoso et al., 2016)
G	Paperclip design problem	Sol	E	(Viswanathan & Linsey, 2013)
B	Commercial building	Sol	N	(Yu et al., 2015)
D	Device to dry apple slices	Sol	N	(Chua et al., 2014)
D	Burrito folding design problem	Sol	E	(Worinkeng et al., 2015)
P, D	Alarm clock problem; The corn shucker problem	Sol	E	(Glier et al., 2014)
P	Device to froth milk	Sol	E	(Toh & Miller, 2015)
P	Toys that aid young children	Sol	E	(Mohedas et al., 2015)
P	Eliminate the need to have multiple bikes as people grow up	Prob	N	(Vasconcelos et al., 2017)
S	Reduce Overdue Accounts/Unpaid Credits	Prob	N	(Moreno et al., 2014)
O	Engineers currently active on design projects	Prob	E	(Cash et al., 2015)

Apart from the differences in how design briefs are structured and the justification for their selection, there are other key factors to consider, such as the number and type of participants, and time allocated to the task (Shah et al., 2000). In most cases, participants are novice students (80%), only one in five include skilled design practitioners. The number of participants varies considerably (between 2 and 398, mode 12), with six studies having five participants or fewer, and five studies including more than two-hundred. Five studies fail to indicate the sample size. In addition, some studies ask participants to work individually (Glier et al., 2014), whilst others work in teams of various sizes and configurations (Kokotovich & Dorst, 2016). Another key variation is the use of rewards such as monetary compensation, academic credits, and/or a bonus monetary prize for the best ideas (Atilola & Linsey, 2015). The data collected vary considerably, from video-recordings (Cash et al., 2015), to interviews

(Veisz et al., 2012), individual journals and meetings transcripts (Cardoso et al., 2016), annotated sketches (Vasconcelos et al., 2017), written statements (Moreno et al., 2014), and models (Viswanathan & Linsey, 2014). Time allocated to ideation activity also varies greatly –a mean of 60 minutes and a standard deviation of 79, with 8.6% allocating fifteen minutes or less, and the same ratio spanning over multiple days or weeks. One in ten studies fail to indicate the time allocated.

This diversity of design tasks exacerbates the alleged artificiality of briefs used in experimental studies (Stones & Cassidy, 2010). Whilst not necessarily a weakness, this diversity is problematic inasmuch as the rationale behind such critical decisions tend to remain implicit and can appear as arbitrary. As a result, the validity and replicability of the findings in the literature are compromised by the lack of means to estimate the best fit between design briefs and other experiment conditions. Our work seeks more explicit means to define design briefs.

4. Synthesis of design briefs

One way to inform the definition of design briefs is proposed here via three indices: polysemy, innovation, and communication. Polysemy refers to the possible meanings for a word or phrase. A polysemy index can be estimated using latent semantic analysis (LSA) to capture ambiguity. This is estimated by comparing keywords used in the brief with the nearest terms in a semantic space using neighbour-to-neighbour pairs (Gallagher, 2013). Words with a lower lexical score are more unambiguous than words with a higher lexical score since neighbours are tightly connected and do not reflect multiple meanings. Briefs with higher ambiguity are more polysemous and they afford more opportunities for reinterpretation by participants. For example, using a Latent Semantic Analysis calculator (Laham & Steinhart, 1998) shows that the term “alarm” presents a higher polysemy than “clock” and “alarm clock”. This can help inform a search in an idea database such as MoreInspiration (AULIVE, 2017). In effect, the terms “alarm clock” and “clock” return closely related cases, whilst “alarm” links to more distant concepts such as the “Wasabi smell alarm” which is not a time-measuring device, yet it can inform the design of alarm clock concepts through the principle of triggering olfactory signals. An olfactory alarm clock that uses scent capsules was launched in 2016 under the name “Sensorwake”.

The potential of a design brief to lead to more original solution spaces can be estimated by assessing the innovation activity related to the target problem, area, or situation. An innovation index can be estimated by searching innovation databases such as MoreInspiration (AULIVE, 2017) or by analysing patenting activity. Here, the innovation index of a design brief is obtained by the mean lifespan of the most relevant patents granted using the United States Patent and Trademark Office database (USPTO). The theory behind this indicator is that concepts with more recent patent activity (lower values) are likely to be more “fertile” or ready for innovative ideas than devices with less recent patent activity (higher values). For example, the ten most recent issued patents for “milk frother” (USPTO Classification 99/323.3) have a mean value of 12.3 years compared to 29.6 years for “digital stopwatch” (USPTO Classification 968/957). More recent activity could mean that the field is undergoing a phase of technology divergence, so re-invention of ideas could be expected. However, high scores may also suggest that the field is due for change, and that participants, particularly experts, could generate truly novel ideas. A measure of variance in innovation scores could be useful, yet a higher score would usually mean increased difficulty to produce original ideas in the design task, for example those that would meet the criteria for patentability. Briefs with recent patent activity could provide a baseline solution to compare solutions generated by participants in the study, or to extract rubrics for the evaluation of those solutions.

Communication indices measure the verbal representation of a design brief using readability metrics, including the Flesch-Kincaid Grade Level and other language processing approaches (Crossley et al., 2017). The Flesch reading-ease test is based on sentence length and number of syllables per word – higher values indicate material that is easier to read, i.e., 70 to 100 points are accessible for school

children, 0 to 30 for college graduate level (Crossley et al., 2017). The Flesch Reading Ease score of a sample of design briefs from articles where the full description is included, shows a range from 34 points (Daly et al., 2016) to 75 points (Glier et al., 2014). Ironically, participants in these two studies were first year engineering students and senior-level engineering students, respectively. These indicators can be used to assess levels of engagement and authenticity (Gulikers et al., 2004).

4.1 Experimental design canvas

We propose a canvas model to structure the decision-making when developing a design brief for creativity research –a mapping framework that could also inform review criteria for manuscripts in order to increase the rigour in this area. This tool is an extension of the "Business Model Canvas", used to explore new business ventures around the description of a value proposition (Osterwalder et al., 2005). A Model Canvas is a tool for creative exploration that allows users to visualise the elements of a model and facilitates discussion, debate, and exploration of potential interconnections and impacts -these models have been shown to assist systemic perspectives (Joyce & Paquin, 2016). Figure 1 shows the canvas with the research question driving the process and shaping the choice of methods, participants' characteristics, ideation mode (individual work or teams) and techniques, the time allocated to the activity, the format and quantity of outputs or deliverables required from participants, the metrics used to assess the outputs, the baseline concepts, the domain experience and skills required to solve the task, and the design brief as given to participants. We focus on this last component and place the three indicators defined above as levers to iteratively develop candidate briefs in relation to all other conditions of an experimental study of design creativity.

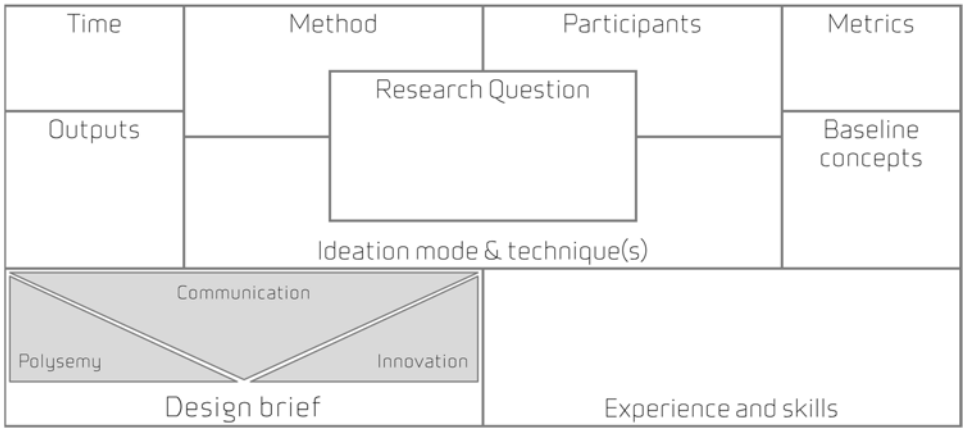

Figure 1. A canvas model for the iterative design of experimental studies of creativity

To demonstrate the value of this canvas model, an illustrative design brief is built here by "reverse-engineering" a concept design winner of the James Dyson Award in 2016. This method can be applied using recent patents, crowd-funded projects, or award-winning concepts with the goal to assess the extent to which participants are able to re-discover such exceptional ideas (awareness of these solutions becomes a criterion for exclusion). The "EcoHelmet" designed by graduate student Isis Shiffer is a foldable and low-cost helmet made in a honeycomb cardboard structure with the intent to encourage the safe casual use of bike sharing services. A number of design briefs could be developed using this solution as a baseline, starting with the actual version of "Design something that solves a problem" as phrased in the original competition brief. The evaluation metrics would then be oriented to capture the breadth of solutions generated by participants, which for the Dyson Award include originality, feasibility, and commercial viability. In order to suit shorter design activities measured in minutes to one or two hours, a second option is to re-orient the brief to "Encourage casual use of bike sharing services", i.e., the main purpose of the EcoHelmet concept. In studies where divergent reasoning is part of the research question, the evaluation rubrics would then reward ideas beyond disposable helmets to nudge potential cyclists to use rental bicycles.

A third option could be to orient the brief explicitly towards the design of the product, i.e., “Kneepads are often not used. How could we design the kneepads to overcome that problem [knee injuries]?” (Franke et al., 2014). Alternatively, the brief could leave the device unspecified and focus on the problem, i.e., “To develop an innovative product that serves as or provides protection for sports or hobbies” (Cheong et al., 2011). In the case of the EcoHelmet, physical protection is seemingly as important as empowering users with a sense of safety to encourage them to ride. The polysemy index can help identify terms that are more suitable based on the decisions made across the canvas model to define the experimental study. For example, the following terms go from lower to higher lexical scores: “helmet”, “head protection”, “head gear”, and “gear” providing a range of orientations for participants during ideation. Using these sorted keywords to search for precedent cases, Figure 2 shows a U-shape relationship with the extreme unambiguous (“helmet”) and ambiguous (“gear”) terms returning a very large number of existing ideas (vertical axes are in log scale) in both Google Patent database and the product catalogue of AliExpress.com. This correlation between intellectual property and commercial products deserves further analysis. In studies with metrics of ideation fluency, both “helmet” and “gear” would be preferable, whilst in those where participants are asked to submit one final concept and focus on originality, both “head protection” and “head gear” are more suitable. In studies with metrics of divergent reasoning, an abstract term such as “gear” may be more suitable than the more concrete and specific “helmet”.

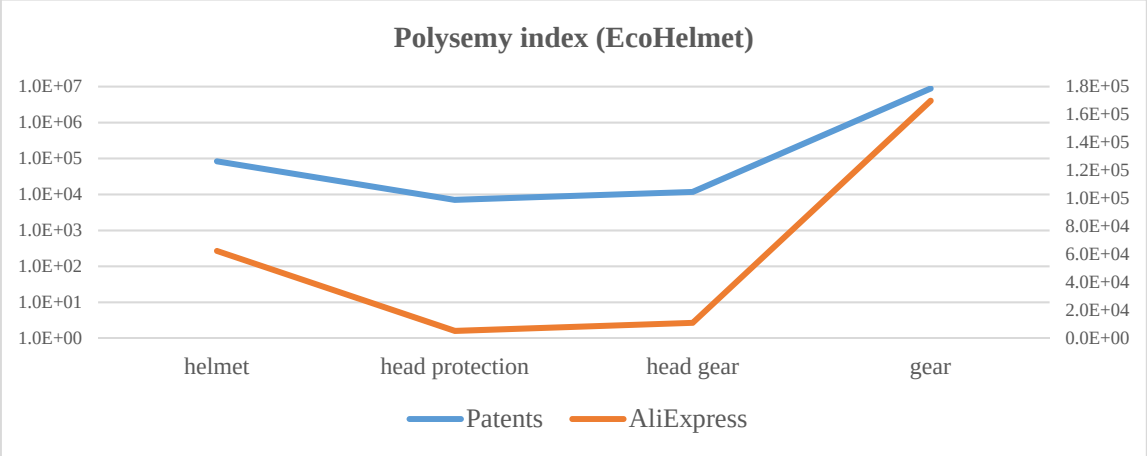

Figure 2. Using a polysemy index to inform search for precedent ideas

To increase specificity (and therefore shorter ideation times and more standardised metrics), the brief could be more narrowly construed to deal with the qualities of the exemplar design, i.e., foldable to save space, low cost, fully recycleable, and a distinctive aesthetic. The brief could ask participants to design helmets for cyclists that meet those criteria using the EcoHelmet as a baseline concept. A similar analysis can be carried to further evaluate possible briefs. Due to limited space, we summarise the innovation activity for related terms based on the number of hits in the USPTO database: foldable (1,260,000), cardboard (1,390,000), disposable (8,220,000), and “low cost” (10,900,000). The gap between the first and the last two terms is significant and indicate that the choice of keyword used in a brief can be reasoned in relation to the other components in the canvas model to shape an experimental study. These indicators still require expert judgement and iterative testing through prototyping of the ideation activity, but they provide an explicit and demonstrable way to synthesise design briefs and could thus help compare outcomes between studies.

5. Conclusions

An analysis of design briefs in the literature reveals a wide variety of research practices and criteria. This paper invites researchers to consider how design briefs may be more suitably defined in future studies, especially in relation to other key experimental conditions. This initial work suggests some

practices including the justification and complete description of tasks as available to participants. In general, it is desirable to formulate design briefs that are less arbitrary and more authentic for participants, i.e., that confront them with challenges that are also carried out in practice and which are deemed by them as relevant, meaningful, and valuable (Gulikers et al., 2004). To this end, evaluation of briefs by participants can be useful.

When design tasks are compared within or between groups, or are given to participants to select, claims of equivalency should be supported with evidence. Establishing baseline solutions for design tasks would demonstrate an adequate understanding of expected or standard outcomes, and would help judges identify extraordinary solutions. These may be based on pilot studies, previous runs, or in gold-standard ideas produced by domain experts, patents, or recent innovations. Extraordinary solutions (either generated a priori by the experts or offered by exceptional participants in the study) should provide alternative understandings of the design task, and could be used to support the reversal of the transformation function that characterises creative design (Goel & Pirolli, 1992). The present inconsistency across the literature means that a meta-analysis in this area is not feasible at this point. One way to increase validity and replicability is to support researchers in the complex challenge of defining design briefs. We believe that the experimental design canvas can facilitate this process, but more work is still required to improve it and detail it further.

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