DESIGN SCIENCE
AN EMPIRICAL AND QUANTITATIVE APPROACH

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1. INTRODUCTION

Open up a photo on an iPhone. You'll see a little icon that looks like a sparkling wand. Press it to 'enhance' your photo. Just like magic, the photo will probably look better. Why? Because science has been making progress to demystify preferences and aesthetics (e.g., Brachmann & Redies, 2017; Cela-Conde et al., 2013; Sun, Yamasaki, & Aizawa, 2018; Yeh, Lin, Hsu, Kuo, & Chan, 2015). It's not just with photos; all the "stuff" that we like are being picked apart. Open up Netflix, there's some films you might like; open up Spotify, there's some new music you might like; open up Amazon, there's some new products you might like. How is this possible? Certainly, these companies are not running focus groups to figure out the preferences of every customer (Stromberg, 2019). Instead, they are building algorithms; they are testing theories; and they are capitalizing on the scientific method (e.g., Linden, Smith, & York 2003; Bennet & Lanning, 2007; Jacobson, Murali, Newett, Whitman, & Yon, 2016). A method, that is providing products which others, who clack clear understanding, are left to interpret as magic. Strickler forewarned in 1999, "if designers do not begin to undertake this important work, others will, and without the benefit of a designer's perspective." The purpose of this paper is to inspire a new generation of designers to research their craft using the scientific method.

2. DEFINITIONS

A secondary aim of this paper is to clean up jargon in design research. Therefore, before moving on, here are some definitions. 'Design research' will relate to the investigation of any question a designer might uniquely have. Broad in definition, this includes ethnographic work while developing a new product, theoretical methods, standards for practice, and pedagogy on sketching—just as examples. Being that design research is so broad, it is appropriate to specify a specific fraction which uses the scientific method and refer to it as 'design science.' For posterity, note that I redefine this jargon to promote straightforward language in design research moving forward. This is as oppose to the definition of design science reviewed in the past (e.g., Hubka & Eder, 1987; Cross, 2001). This point is explained a bit more fully in the following paragraph. Finally, 'scientific method' refers to the use of "systematic observation and experimentation, inductive and deductive reasoning, and the formation and testing of hypotheses and theories" (Anderson & Hepburn, 2015); see figure 1 for an illustration. In practical terms, 'scientific method' is defined here as the use of statistical tools to test claims; an empirical and quantitative epistemology.

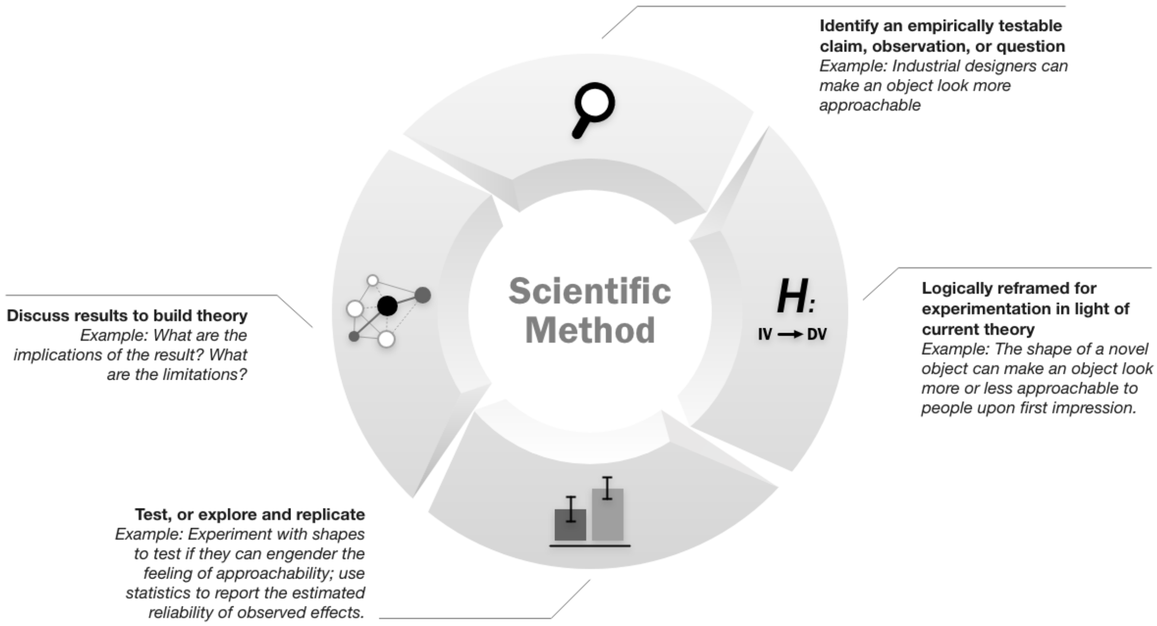

Figure 1. A visual representation of how the scientific method can help build knowledge in design science. Using statistics, intuitions can be rigorously tested. The results of which contribute to refined theories, which in turn can lead to new insights. (A conceptual reproduction of figure 1.1 in Cash, Stanković, & Štorga, 2016).

3. HISTORICAL BACKGROUND

The relationship design has had with the scientific method in the past is convoluted. In 1957 Buckminster Fuller redefined science for many designers. He claimed that design was a different kind of scientific discipline, yet nonetheless scientific simply because it attempts “to set in order the facts of experience” (Fuller, 1957). This definition is obviously insufficient because, by this logic, many pseudosciences, such as astrology or physiognomy, could be considered a science. Thus, the design science of the past is a misnomer because it lacks the same scientific method shared amongst other scientific disciplines. In order for design science to be appropriately named and actually produce scientific evidence, empirical and quantitative tools, such as statistics, must be used in research (for an analogous argument, see Marshall, 2012). There was a notable attempt made in 1972 to explore this possibility (Davis & Gristwood, 2016). The Royal College of Art opened the Department of Design Research, with Professor Bruce Archer at its helm. Unfortunately, the hope that the scientific method could be useful to understand the designer’s practice waned (e.g., Archer, 1979), and the department closed in 1984. Today, a rigorous use of the scientific method to evidence claims is largely absent across published design research (Cash, Stanković, & Štorga, 2016; Norman, 2010). Perhaps this is why over 80% of new products fail at launch (Broadbent, 2004).

4. GETTING STARTED

By conducting tests and through replication, design science can begin to build an understanding of preferences, aesthetics, and other human factors. To get started, design scientists can draw from the methods developed in scientific disciplines such as psychology (Archer, 1968; Bayazit, 2004; Robinson, 2016). Other germane disciplines include human computer interaction, consumer psychology, cognitive science, human factors, and ergonomics. One important concept to understand when studying abstract concepts is the notion of ‘operationalization.’ Psychological concepts, such as an impression of beauty, needs a rational method for measurement. The process of quantification is called ‘operationalization.’ To measure beauty, for example, previous researchers have operationally defined it as: looking time (e.g., Cacchione, Möhring, & Bertin, 2011); pupil dilation (e.g., Alvarez, Winner, Hawley-Dolan, & Snapper, 2015); reaction time (e.g., Rolke, Stepper, Seibold, & Hein, 2019); a self-report measurement on a scale from 1, not at all beautiful, to 9, extremely beautiful (e.g., Kurosu & Todorov, 2017); a self-report measurement using the distance between one’s index and middle fingers (Brielmann & Pelli, 2017); and patterns of brain activity (e.g., Cattaneo et al., 2014; Yeh, Lin, Hsu, Kuo, & Chan, 2015). With operationalization experiments can be conducted and the benefits of doing a quantitative statistical analysis includes greater precision in estimating the relationships between concepts and more reliable predictions.

5. NOTABLE EXAMPLES IN EXISTING RESEARCH

There exist some notable examples of scientific research designers today could take inspiration from. Take ‘design thinking’ for example. One of the few empirical studies examining it, found evidence that it may be able to improve a person’s creativity (Ohly, Plückthun, & Kissel, 2017). To show this, they administered a creativity test before and after a design thinking program. Then they used statistics to determine if the creativity scores were significantly higher (relative to random chance) at the end of semester. They found that the average creativity score was not higher after the program. However, if a student was satisfied with the team they worked with, they were significantly likely to report being more creative after taking the design thinking program. This complex relationship between concepts, otherwise known as an ‘interaction effect’ in psychology, is an example of the kind of precise insight design scientists can gain from incorporating statistics into their research.

Another topic designers may be interested in researching scientifically is aesthetics. With color, there is the ecological valence theory which theorizes that people’s preferences for colors are linked to their preferences for the objects they readily associate with the color (Palmer & Schloss, 2010). In other words, if green is your favorite color, it might be because you think favorably about the things you associate with green. With taste, there is interesting multi-sensory research being conducted by Charles Spence at Oxford University. For example, it has been shown that rounder typefaces make food taste sweeter (Velasco et al., 2017). With shapes, people generally prefer curved-contours over angular-contours (Gómez-Puerto et al., 2017). Recently (2018), Che, Sun, Gallardo, and Nadal published a review of the scientific evidence supporting cross-cultural aesthetic properties and it includes concepts such as symmetry, proportion, and contrast.

6. FUTURE RESEARCH

If you are unsatisfied with the current level of understand scientists have about aesthetics, be excited about your potential opportunity to contribute a scientific fact! A notable study by Kurosu and Todorov in 2017, laid groundwork designers can use to scientifically understand aesthetics. How they accomplished this was by developing rigorous empirical evidence for the claim that shapes can elicit different kinds of impressions. Imagine, for example, that you are designing an object that looks approachable. You may also be surprised to know that until that study was published, there existed no rigorous scientific evidence to support the claim that you could accomplish such a task. Kurosu and Todorov provides a framework for studying the relationships between impressions and shapes. Therefore, if you have an idea for why certain shapes look approachable, the paper outlines two important measurements you must consider: consistency and consensus. Consistency means that people hold onto their impression over time, and consensus means that multiple people share the same impression. Without consistency in a behavior, the impressions being generated are likely arbitrary. Without consensus across people, it’s likely that the impressions being generated are idiosyncratic or varies culturally. Future designer researchers should test their intuition and look for the boundaries of consensus and submit a contribution to science. With time, design scientists can build a corpus of knowledge. Imagine if you were in design school and you had a book that was filled with information about how certain shapes elicited different impressions across different cultures? Imagine if you were in an executive meeting and you pitched a product design that you knew would seem approachable for 95% of your target users?

7. CONCLUSION

In conclusion, the designers of the future could benefit from the advent of an empirical and quantitative design science. In a study by Maya and Gomez (2015), hundreds of pedagogical methods in design were analyzed and amongst the 13 different categories none included the scientific method. Design educators today are therefore encouraged to introduce the scientific method into their curriculum. By providing students statistical tools, they will be given a chance to understand their craft beyond what is currently taught; e.g., notions of affordances, product semantics, and gestalt principles (e.g., Shankwiler & Schaar, 2008). Furthermore, familiarizing industrial designers with scientific discourse could help them collaborate with artificial intelligence researchers, marketers, and human factors researchers. Which could also help designers find the ergonomics literature a more useful resource for their practice (for an overview of the problem, see Goodman, Langdon, & Clarkson, 2007). As designers start to learn the common language of other scientific disciplines, the legitimacy of a design expertise may become more readily apparent (for a characterization of the problem, see Briede, Cabello, Cartes, & Vargas, 2014).

To be clear, while the focus of this paper has been on quantitative design research. This isn’t to say that qualitative research should be discontinued. After all, storytelling is a proven tool for bridging understanding (Nguyen, Vanderwal, & Hasson, 2018), and remembering particular details (McGregor & Holmes, 1999). As a discipline, the stories designers tell each other has been how they’ve learned from each other (Howard & Gray 2014)—that is, aside from learning through years of personal experience (Lawson 2004). Furthermore, storytelling is a powerful tool in the product development process (e.g., Beckman & Barry, 2009). Nevertheless, the purpose of this paper was to encourage another form of learning in the industrial design discipline. With the scientific method, designers can test and share true insights to grow the standard level of talent.

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