11-2020

An Empirical Investigation of the Dimensions of Product Similarity used in Design by Analogy of Electromechanical Products

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by

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A thesis submitted to the College of Engineering and Science at
Florida Institute of Technology
in partial fulfillment of the requirements
for the degree of

Master of Science
in
Mechanical Engineering

Melbourne, Florida
November, 2020

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Abstract

"An Empirical Investigation of the Dimensions of Product Similarity used in Design by Analogy of Electromechanical Products"

Arnold Nkoane Tsoka

Advised by Chiradeep Sen, Ph.D.

Analogical reasoning is known to be a core cognitive mechanism behind creative human tasks including the creativity in engineering design. Research shows that during product ideation, designers use analogy to transfer information from prior designs stored in their memory (the source of the analogy) to the task in hand (target of analogy). However, similar to any search process, the source product must be first identified as a potential candidate for analogy before this information transfer can take place. Two products can be similar along multiple dimensions such as their form, function, etc. The dimensions of similarity between two products that designers use in their cognitive domain to identify a product as a potential source of analogy for a given target product have not been investigated in prior research. This research addresses this gap through multiple empirical human-subject experiments that show evidence for up to eight different dimensions of product similarity that designers (experiment subjects) used for this purpose.

Two different studies, namely the "pilot study" and the "main study", were conducted using total one hundred voluntary participants. Each participant was presented with a product to be designed (target), described with a photo and name. The designer was asked to identify potential source products of analogy for the design from a list of options, where each potential source was also described with photos and names. Designers were then asked to indicate the reason why they thought each source would be useful for the design. In the pilot study, fifty designers designed three target products each, and they indicated their rationale by choosing dimensions of similarity from a list of five options, thus producing 50 designers × 3 target products × 5 source product options × 5 possible dimensions = 3,750 data points. In the main study, an additional fifty designers solved two target products each, and they explained their rationale in plain-English. Semantic analysis of this written text revealed the possibility of eight different

dimensions, thus producing 50 designers × 2 target products × 5 source product options × 8 possible dimensions = 4,000 data points (although only 2,440 were used after rejecting the invalid ones). Analysis of this large amount of data shows that designers use up to eight dimensions of analogy, namely, *working principle, function, structure, energy flow, human interaction, material flow, behavior and purpose of the products*. The data suggests that the first six dimensions account for over 99% of the analogy instances, while evidence for the last two dimensions is insufficient. Among the first six, the first four account for 86% of analogies. Thus, this research shows that there are at least six discernable dimensions of product similarity that designers use to identify potential source products of analogy for designing a given target product.

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Acknowledgement

Firstly, I would like to thank my advisor, Dr. Chiradeep Sen, for ushering me to the design engineering field and community. Without Dr. Sen's continual support and assistance, this thesis would not be complete. Secondly, I would like to thank the Tsoka family for their support and love. I know a lot was sacrificed in order to help me achieve. Narasimhon Lakshmi, Ahmed Chowdhury, Amaninder Gill, Jicmat Tribaldos and Devanshi Shah, thank you for making the RiSE research group feel like a family. Last but not least, I would like to thank my American host family for their unwavering support and love, thank you Mr. and Mrs. Wharton.

Dedication

“Education is the most powerful weapon which you can use to change the world.”

-Nelson Rolihlahla Mandela

Chapter 1: Introduction

This chapter briefly introduces the overall research problem and gap, the concept of dimensionality of product similarity and analogy, the specific research questions and hypotheses of this research, the research approach taken to answer the research questions, and some important definitions on which this research stands.

1.1 Research Gap and Motivation

In his 1956 address to the American Psychological Association, celebrated theoretical physicist and the head of the Manhattan Project Robert J. Oppenheimer predicted the inevitable development of analogy into a "well-developed, highly-organized, highly-formalized, and highly coherent science" [1]. Today, analogy is understood to be a core cognitive mechanism behind creative human tasks including the creativity in engineering design. For example, in cognitive psychology, analogical thinking has been demonstrated to play a pivotal role in creative problem solving by Gick and Holyoak [2]. Similarly, Gentner et. al.'s Structure-Mapping Theory provides a cognitive mechanism, in which analogies are formulated on the basis of key similarities that exists within domain relations, rather than the form or structure of the objects alone [3].

In engineering design, analogy serves as a process in which the human mind or a computer program identifies products from the long-term memory or other datasets as possible sources of analogical reference for solving the design problem in hand (i.e., the target of analogy), and transfers information from the source to the target domains [4,5][6,7]. This ability to map existing information or knowledge to the new problems enables the reuse of knowledge and prevents redundancy of design effort. The analogical distance between two products, i.e., the apparent dissimilarity between them, has been shown to have a clear effect on the efficacy of ideation by human designers [6].

Within the engineering design research community, investigations into the role of analogy has resulted in a field called Design by Analogy (DbA). Research has focused both on scientifically understanding the role of analogy in design and on building design methods and tools that facilitate or simulate design by analogy. For example, analogical reasoning by human beings inherently depends on source solutions stored in the individual person's long-term memory that reflects the person's life experiences, and this limitation is known to cause design fixation [8–12]. To address this limitation, design by analogy tools such as AskNature [13] and DANE [14] facilitate analogizing based on an option-set that resides

outside the designers memory, in a computer database, and can therefore contain much larger amounts and wider varieties of data from which analogy could be built during design. Both of these tools are specifically designed to draw analogies from the biological domain, and serve as bio-inspired design tools.

However, similar to any search-and-retrieve process, the source product must be first identified in the designer's cognitive domain as a potential candidate for analogical reference before the information transfer from the source to the target problems can take place. Two products can be similar along multiple dimensions such as their form, function, etc. The dimensions of similarity that human designers use to identify a product as a potential source of analogy for a given target product have not been previously investigated in detail. This research addresses this gap through multiple empirical human-subject experiments that show evidence for up to eight different dimensions of product similarity that designers used for this purpose.

The DbA tools mentioned above mainly rely on function-based similarity between the source and target products as the basis of analogy [5,13–15]. This commitment is not wrong or unnatural, especially since design has been classically accepted as a process of deriving form from function [12,16–18]. However, some recent studies indicate that the formation of analogy may rely on other types of similarity between products such as similarity of flow types, flow attributes, form, and human interaction [19,20]. Arguably, if analogy in design could be shown to be driven by more than just function-based similarity between products, then design tools could possibly be built that would recommend analogical references based on these other dimensions of similarity, which could further facilitate design ideation. It therefore merits examining the dimensions of product similarity that contribute to the formation of analogy in design, which provides the motivation behind this research.

In the next two sections, the dimensionality of product similarity used studied in this research and their definitions are illustrated.

1.2 Dimensions of Product Similarity

The dimensionality of the similarity between two products is a core concept of this research. This section explains this concept with examples and defines the eight dimensions used in this research, for the ease of comprehension.

Two products can be similar in many different ways, and the dimensions of their similarity, loosely speaking, are the answer to the question: "in which ways are the two products similar"? For example, the hairdryer, heat gun, and drill gun products shown in Figure 1 generally share the same shape recognizable by human designers – a gun shape

with a pistol grip and a squeezable trigger. Thus, they are similar along the dimension of "shape". In addition, the hairdryer and the heat gun also share similar overall functionality, which is to produce a stream of hot air. The drill gun, by contrast, does not share this function, and therefore is not similar to the other two products along the dimension of "functionality". Thus, this example illustrates two dimensions of product similarity, namely, shape and functionality.

Hairdryer **Heat gun** **Drill gun**

Figure 1: Three products that share different similarities in shape and functionality

It should be noted that the detection of two products to be similar along a specific dimension depends on the ability of the detecting agent. For example, a human observer might recognize the three products in Figure 1 to be of similar shapes. A computer program, which looks for exact match of shape dimensions or topology such as shape recognition programs used in computer-aided design (CAD), may not recognize them to be similar due to the lack of an exact match. By extension, a well-trained machine learning program could potentially detect them as similar. This research excludes this variation in perceived similarity due to the variation of the detecting agent. It only focuses on the perceived similarity as detected by human agents, i.e. voluntary designers.

The dimensions of similarity examined in this research were compiled from two well-recognized theories of engineering design, namely the Systematic Design model [21] and the Function-Behavior-Structure model [22]. The Systematic Design model shown in Figure 2 describes the following domains of design information that are distinct from each other: customer needs, technical requirements, functions, working principles, working structures, components, their forms (shape, size, material), their physical layouts, and their specifications, and the assembly of the solution. A design process, while iterative, generally passes through these domains in succession as the process transitions from the problem state to the solution state. Similarly, the FBS model shown in Figure 3 recognizes that design is an interaction between the function, behavior, and structure of the

solution. In this model, the requirements (R) are derived into desired functionality (F), from which expected behaviors (B_e) are derived. The structure (S) is synthesized from these three previous domains, and produces its actual behavior (B_s), which may not match the expected behavior (B_e). Therefore, an iteration ensues, and the design (D) is produced when the two behaviors match to a satisfactory extent. While the terms function and structure discussed in the FBS model are similar to the terms function and form in the Systematic Design model, the concept of behavior is unique to the FBS model.

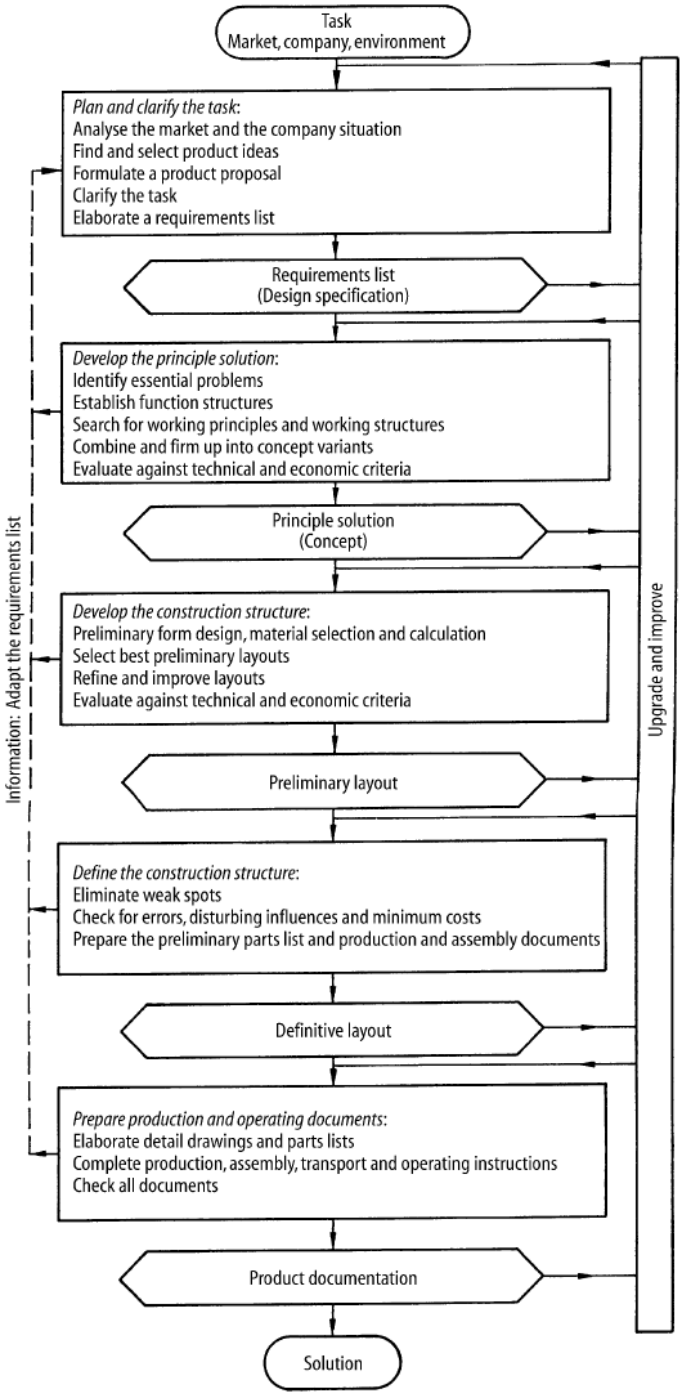


Figure 2: The systematic design model [21]

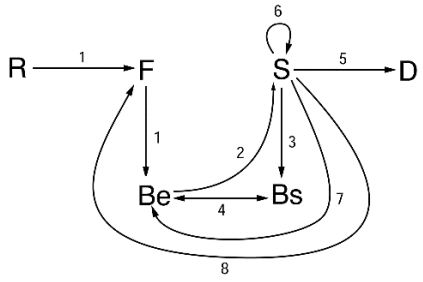


Figure 3: The function-behavior-state model (FBS) [22]

Based on the above understanding, the following eight domains of design information are used in this research as the dimensions of similarity between products: *purpose, human interaction, function, behavior, structure, working principle, energy flow, and material flow* through the products. These dimensions are defined in the next section.

1.3 Definitions of the Dimensions of Product Similarity

The eights dimensions of product similarity examined in this research are defined below with examples. These dimensions are common and important keywords in design research, and as such have been defined in design texts [8,23] and research literature [20] previously. However, some of these keywords have been defined in multiple different ways in literature [24,25]. These terms are defined here for this research project, in order to establish clear references against which the data from the experiment were codified.

1.3.1 Function (F)

For this research, function is defined as *"an activity executed by the device for carrying out an objective"*, after [14,26,27]. Alternately, function is the answer to the question: "*What does the artefact do"?* [24]. Note that this definition subsumes other widely regarded definitions, such as Pahl, et. al.'s definition: "the intended input/output relation of a systems whose purpose is to perform a task" [21], or Culley's definition: "the desired output from a system"[28]. For example, in an electric hairdryer and its subsystems, the statements such as "to produce a hot stream of air", "to heat air", "to produce heat", "to propel air", or "to create a flow of air" are all descriptions of what the devices do in order to satisfy their requirements, and they count as functions. By this definition, a hairdryer and a room air heater are functionally similar (to produce hot air), but a hairdryer and a doorbell are not.

1.3.2 Working Principle (WP)

For this research, the working principle of a device is defined as the answer to the question: "*how, i.e., using which principles of science or engineering, does the device accomplish its function*"? Note that this definition is closely similar to the classical definition by Pahl, et. al. [21]. For the hairdryer example above, the function "to produce heat" could be achieved by a variety of physics principles such as resistive heating of electric current, friction, combustion, by focusing sunlight using a lens, or by electric discharge. Each of these techniques are means to accomplish the function, but is not the function itself. These means count as working principles. By this definition, a hairdryer and a toaster oven has similar functions (to produce heat) and similar working principles (resistive heating). Conversely, an electric motor and an internal combustion engine satisfy the same function (to produce rotational motion) using different working principles.

1.3.3 Behavior (B)

The definition of behavior for this research is in accordance with Gero, et. al. [22] and Chen, et. al. [23], who described it as "*attributes that are derived or expected to be derived from the structure*" [22] and "*the behavior of an entity refers to its own state change in its life cycle periods….which usually deals with the causal behaviors for achieving a desired function*" [23], respectively. For example, the sound produced by a hairdryer, or the heat, sound, vibration, and smoke emitted by an internal combustion engine refer to state changes that are causal consequences of the device's working principles that do not qualify as the devices' functions, because functions allude to the intended actions of the device. These side effects and/or consequences are called behavior.

1.3.4 Material Flow (M)

For this research, material flows are *the materials flowing into and out of the product, and all the interim states in which it exists inside the product*. This definition is derived from function-based design literature, such as [21].

For example, in a drip-type coffeemaker, the input material flows are coffee grinds and cold water, the output material flows are the brew, the used-up grinds, and the steam leaving the device, and one interim flow is the hot water residing within the system. Similarly, a hairdryer has cold air and hot air as its material flows at input and output, while a doorbell has no material flow. Thus, a hairdryer and an air conditioner are similar in terms of material flows, but a hairdryer and a coffeemaker are not.

1.3.5 Energy Flow (E)

For this research, energy flows describe *the types of energy that can be identified at the input, output, or in between within the product*. For example, a hairdryer and a doorbell are similar in terms of input energy (electrical), while a mechanical alarm and a doorbell are similar in terms of output energy (acoustic). The hairdryer and the mechanical alarm are not energy-wise similar, not counting the sound of the hairdryer, which is more closely associated with its behavior but not its intended function.

1.3.6 Structure (S)

For this research, the structure of a product is *the description of its form, physical properties, and the connections and relations between the physical components*. In this sense, structure derives the definition of "form" in the Core Product Model [29]. For example, a hairdryer, a drill gun, and a hot glue gun all share the structural feature of the pistol grip and squeeze trigger. The grip has a similar geometry and material among all three products, and the relation between the trigger, the springs, and the grips is also common between them, while the differences are mainly in the quantitative details such as the size of the levers, the spring constants, and the force needed to squeeze, etc. The three products shown in Figure 1 are also recognizable as structurally similar.

1.3.7 Purpose (P)

For this research, a device's purpose is the customer-centric answer to the questions "*why does the product exist*" or "*why is the product needed*" or "*why does the customer want the product*"? Note that this definition deviates from some previous ones such as Chakrabarti [30], who proposed two viewpoints for purpose: one at the same abstraction level of intended behavior and the other called the function-based purpose. For example, the purpose of a hairdryer and a drill gun are "to dry hair" and "to make holes", respectively, both of which describe the user's reason for using the device, instead of what the device does (function) or how it does it (working principle). By this definition, a drill gun and a three-hole punch have the same purpose (to make holes), but different structures, different functions, and different working principles.

1.3.8 Human Interaction (HI)

Human interaction describes *how the product interacts with the user.* This dimension includes both physical and cognitive ergonomics. Physical ergonomics considers safety, suitability, and comfort of the product with users [31,32], whereas cognitive ergonomics refers to motor response and perception [33]. For example, all touchscreen devices are similar to each other in terms of human interaction, and all devices with pistol grip are also mutually similar. However, a door knob is not similar to a door bolt in terms of human interaction, although they have the same purpose.

As illustrated above, products can be similar in one or more dimensions. The objective of this research is to discover the dimensions that are used by human designers to detect a product (source of analogy) as a potentially useful reference for analogical transfer of information to the design of another product (target of analogy). The next section formally presents the research questions and hypotheses of this research.

1.4 Research Questions and Hypotheses

The research questions (RQ) and hypotheses (H) of this research are presented below. The research questions were examined through a pilot study and a subsequent main study, separated by more than one academic semester. As a result, the hypotheses statements for the RQs were worded slightly differently for these two studies, based on what was known at the time in each case, as shown below.

1.4.1 Research Question 1

RQ1: Which dimensions of similarity between two products are used by designers to identify one product as a possible source of analogical reference for designing the other (target) product?

H1.1: For the pilot study: Designers recognize a product as a source of analogy during the solution search based on at least five dimensions: function, form, motion, energy flow, and material.

H1.2: For the main study: At the minimum, the dimensions of function, working principle, behavior, purpose, structure, material flows, and energy flows through the product are used by designers for the aforesaid purpose.

1.4.2 Research Question 2

RQ2: Are some dimensions of product similarity more dominant than the others in the formation of analogical reference between the source and the target products?

H2.1: For the pilot study: Function-based similarity is more dominant than the other types of similarity in the aforesaid purpose.

H2.2: For the main study: Function-based similarity is the most dominant dimension of product similarity used by designers for the aforesaid purpose.

The next section briefly describes the research approach undertaken to answer these research questions and to test these hypotheses.

1.5 Research Approach and Summary of Outcomes

The research reported in this thesis was completed through two human-subject studies, namely the "pilot study" (Chapter 3:) and the "main study" (Chapter 4:). They included total one hundred voluntary participants, and their protocol was approved by the institutional review board of the author's home institute, Florida Institute of Technology. The goal of the pilot study was to test and refine the method of the experiment and to ascertain that they are likely to produce valid data that could be used to test the hypotheses (Section 1.4). The main study was a larger and more elaborate version based on the lessons learned from the pilot study.

In both studies, each participant was presented with a product to be designed (target of analogy), described with a photo and name. The designer was then asked to identify potential source products of analogy for the design from a list of options, where each potential source was also described with photos and names. Designers were then asked to indicate the reason why they thought each source product would be useful for the design of the target product. In the pilot study, fifty designers designed three target products each, and they indicated their rationale by choosing dimensions of similarity from a list of five options, thus producing 50 designers × 3 target products × 5 source product options × 5 possible dimensions = 3,750 data points. In the main study, an additional fifty designers solved two target products each, and they explained their rationale in plain-English. Semantic analysis of this written text revealed the possibility of eight different dimensions, thus producing 50 designers × 2 target products × 5 source product options × 8 possible dimensions = 4,000 data points (although only 2,440 were used after rejecting the invalid ones).

Analysis of this large amount of data shows that designers use up to eight dimensions of analogy, namely, *working principle, function, structure, energy flow, human interaction, material flow, behavior and purpose of the products*. The data suggests that the first six dimensions account for over 99% of the analogy instances, while evidence for the last two dimensions is insufficient. Among the first six, the first four account for 86% of analogies. Thus, this research shows that there are at least six discernable dimensions of product similarity that designers use to identify potential source products of analogy for designing a given target product.

The remainder of this thesis document is organized as follows. Chapter 2: presents a brief review of the pertinent previous research upon which this research is built. Chapter 3: presents the first of the two studies conducted within this research, namely, the pilot study. Chapter 4: describes the second study, called the main study. In each case, the design of the study, the study instruments, the data, analysis, observations, and

inferences are presented. Finally, in 4.4, presents the conclusions from the studies, the answers to the research questions, a summary of the research contributions, and a discussion on the future research directions produced from this work.

Chapter 2: Review of Prior Research

Analogy is a cognitive process of transferring information or meaning from a particular domain to another. The analogical process involves noting shared characteristics of two or more items, and inferring that they share some similarity. Research from across varying fields has shown that analogy plays an important role in problem solving. The integration on analogy in design engineering has resulted in an area of interest called Design by Analogy (DbA). This chapter briefly reviews the prior research in analogical reasoning.

2.1 Analogy in Cognitive Science and Psychology

In the research of children's psychological development, studies have explored how relational complexity and feature distraction can have an impact on children's analogical reasoning performance, as varied scene analogy problems where the results suggests that analogical reasoning improves with increased relational knowledge as well as increase in age [34]. Another research group relating to the psychological retrieval investigated the use of analogy from a semantically distant domain as a guide to problem solving where a control group was provided with an analogical story in between problem presentation and solution search and the experimental group was provided with none, from which the researchers noted a contrasting difference in the use of analogy between the control and experimental groups [2]. In the investigation of students who had been told folk tale during childhood, researchers observed that visual cues play a role in long term memory transfer and analogous problem solving [35]. Educational research has supported the importance of analogous problem solving method where the influence of structure and context in the solving of algebraic word problems was investigated by pre-service teachers. The educational research in this directions has resulted in findings which point out that problems are more difficult to solve when they have a complex structure and a context of low familiarity [36]. The detection of similarity as a human cognitive process has been modelled as a process that clusters the stored exemplars and is predicted on share properties in addition to relational structures [37].

2.2 Analogy in Engineering and Design

In engineering research, there exist a structure-mapping theory which formalized analogy as a relational structure [3], and in addition to this formalized analogical relation, analogy can also be based on other dimensions such as function and form. As a matter of fact, there exists other several methods of detecting similarity and use of analogy in literature. For example, there exists several methods of measuring and utilizing physical similarity

between products and designs. In the measuring of similarities between 3D CAD models, techniques such as shape recognition and shape signatures have been evaluated for application [38,39]. In the study to combine shapes of automobiles from different classes in order to create crossover vehicles, varying shape grammars have been proposed to study the similarity of form among complex product categories like Harley Davidson motorcycles and Buick automobiles [40–42]. There also exists studies in which silhouette shape similarity of existing automobiles was used in an Interactive Genetic Algorithm to generate novel and innovative automobile silhouette shapes [43].

Beyond shape and form similarity, analogy between products can also be based on functional similarity. In systematic design process function structures (models) are used to construct relationships between sub functions with the goal of accomplishing the overall function, the function structure model describe the actions of a device in terms of transformation of energy, material, and signal [16,17,44]. Other studies in relation to function structure models have also shown that the ability of human observers to identify the product as a source of analogy improves if the auxiliary sub-functions were removed from the model [26,45]. Using function structure models, McAdams et al [46] proposed a matrix based similarity approach that maps the customer needs on to function models to determine individual function importance scores, the sum of which gives the importance score for the products being compared. This function similarity method has also found application in using function models to predict failure in high risk aerospace endeavors [47] in addition to being used to find similarity in families of products [26,45]. In function based designs, a study has also been conducted on the analogies that the designers used while designing a novel product as described by its function found that flow behavior was found to be the common way to abstract similarity in order to draw analogical connection [19].

Design by Analogy (DbA) has been shown to adequately serve as catalyst for creativity by helping designers to identify existing solutions analogous to the problem at hand [48,49]. Several DbA methods such as biologically-inspired design have been proposed to use analogy to aid designers in creative design, which makes it possible to use functional similarity between biological systems and technical engineering systems to synthesize form for the technical engineering system inspired by the biological forms found in nature [49]. Large-scale implementations of DbA in the field of bio-inspired design, such as AskNature[1] or DANE[2], also mainly rely on searching for biological structures that deliver searched functions [48]. However, recent protocol studies that examined the mental meta-models of analogy during sketching solutions to novel design problems suggest that

[1] https://asknature.org/, accessed on October 24, 2020
[2] http://dilab.cc.gatech.edu/dane/, accessed on October 24, 2020

analogy could be based on more than just functional similarity between the design task and the analogical solution retrieved from long-term memory [19].

DbA based support and ideation methods developed so far have been predicated on the structure-behavior-function of overall products [5], on the similarity of sub-functions [15,50], and by using functional synonyms and antonyms. A detailed review of DbA literature done by Chakarbarti and colleagues [51] concluded that the biggest chunk of work in this area has been carried out to fulfill intended functionality. Recent protocol studies that examined the mental meta-models of analogy during sketching solutions to novel design problems suggest that analogy could be based on more than just functional similarity between the design task and the analogical solution retrieved from long-term memory [19], while other studies indicate that the formation of analogy may rely on other types of similarity between products such as similarity of flow types, flow attributes, form, and human interaction [19,20]. Arguably, if analogy in design was shown to be driven by more than function-based similarity, design tools could possibly be built that would suggest analogical references based on those other types of similarity, which could further facilitate design ideation. It therefore merits examining the dimensions of product similarity that contribute to the formation of analogy in design, which provides the motivation behind this research.

Chapter 3: The Pilot Study and Its Findings

The pilot study is the first of the two studies reported in this thesis. It was the precursor to the main study reported in Chapter 4:, and its objective was to examine the feasibility of the method of study undertaken and to obtain some initial data that could potentially inform the design of the main study. In the end, the pilot study produced valuable evidence that supported, at least partially, both the hypotheses and provided a direction to the design of the main study described in Chapter 4:. The protocol of the study was approved by the Institutional Review Board of the authors' home institute, Florida Institute of Technology.

3.1 Design of the Pilot Study

The pilot study investigated the similarities between target and source products on five dimensions: **structure, function, motion, energy flows, and material flows**. Voluntary participants were presented with electromechanical products described in photographs and written names, and were asked to imagine that they were to design those products. The products to be designed are called the target products. For each target product, participants were shown five other electromechanical products and were asked to identify the product(s) that could serve as useful sources of analogical reference for designing the target product. These products were called source products. In addition, the participants were asked to choose the dimensions of product similarity that were perceived to contribute to selecting the source products. The objective of the study was not to obtain or evaluate the designs or the designers of the products, but to explore the dimensions of similarity that designers recognize as a source of analogy.

3.1.1 Participants and Training

The voluntary participant pool for the study consisted of fifty students majoring in Mechanical Engineering, who were enrolled in a junior-level Theory of Machines class. The students were in good academic standing as juniors or seniors as of Spring 2019. Extra credits in the course were offered in order to reward the participants for their participation and to ensure that they provide reliable data. The study was conducted in class, with all students in attendance present in the same classroom at once.

All the participants were put through a brief training session in order to familiarize them with the concept of product similarity. During this session, the participants were reminded of the recommendations that e-commerce website like Amazon.com produce

using analogical reasoning to help a purchaser find products that are similar to the one searched. They were also asked to think of how such a hypothetical web-service could be helpful if its suggestions were optimized to help a designer obtain ideas for a product that they were trying to design. The study instrument and the participants' experience emulate a designer searching for alternate designs that could stimulate analogy to the product being designed. The participants were also familiarized with the design instrument and the tasks to perform prior to data collection.

3.1.2 Selection of Target and Source Products

The products for this study were selected using a two-step process. In the first step, five **target** products were selected using the following criteria: the products should be potential familiar to the participant demographic (American college students), electro-mechanical in nature, and of reasonable complexity. The five products selected were: **Room Heater, Glue Gun, Hair Dryer, Drill, and Blender**.

In the second step, for each target product, five **source** products were selected, thus making it a total of 25 source products. Two selection criteria were used for these products. The first criterion was the same as that for the target products. The second criterion was that the source products for a given target product must produce different combinations of functional and structural similarity with the target. According to the degree of functional and structural similarity, each source product received a number designation of the (x, y) form, as shown in Table 1.

Table 1: Numbering convention for source products based on the nature of similarity with the target product

Number designation of source (x, y)	Functional Similarity with target (x-axis)	Structural Similarity with target (y-axis)
(0,0)	No	No
(0,1)	No	Yes
(0.5,0.5)	Partial	Partial
(1,0)	Yes	No
(1,1)	Yes	Yes

To help with designing the source and target products, the source products are placed on an ordinal system, an example of which is shown by Figure 4. In order to determine the

placement of the source products on this ordinal system, their function and form were examined. Using past experience in function modeling, the function similarity between the source and target products was determined by consensus between the graduate student researchers within the RiSE research group. To evaluate the similarity in the form of the object, a shape grammar-based approach was taken, and it must be noted that this approach is somewhat subjective.

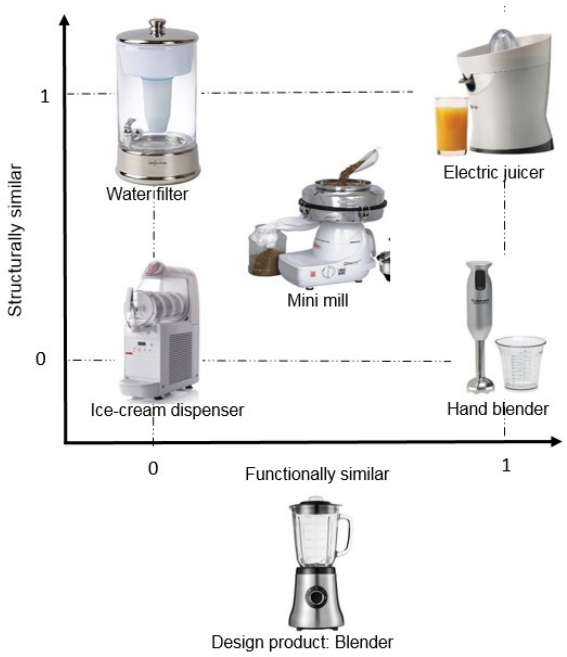


Figure 4: Graph representation of product ranking

In the example above, the target product presented to the participant is the blender. The ice-cream dispenser is denoted as the (0,0) point, given its structural and functional dissimilarity with the blender. The hand blander is functionally similar and structurally dissimilar, thus located at (1,0). The mini mill is somewhat functionally and structurally similar, and hence placed at the center location on the graph, at (0.5,0.5). The juicer is deemed similar to the blender both functionally and structurally, and is therefore placed at (1,1). The water filter, which is functionally dissimilar to the blender but appears to bear visual and structural resemblance to it, is placed at (0,1). By ensuring that for each target product, the five source products presented to the designer occupied these five points on the ordinal system of Figure 4, it was ensured that the source products were diverse enough to catch if function and/or form was the main driving dimension in the detection of sources as analogical references.

3.1.3 Design of the Study Instrument

A paper-based survey, as shown in Figure 5, was used as the study instrument. The target product was displayed at the top of the page with photo and name. Below it, images of the five source products were placed. The other five variants of the survey are shown in Appendix A:. The question that the participants were asked was “Which of these suggestions would you like the database to return when you search for design ideas for the product above?”. This sentence refers to the hypothetical design-assisting tool or database, to which the designers were familiarized during the training session. A check box was provided under each of the source products for the participants to select the product they would like to see suggested, if they were designing the target product. The participants were also asked “Why did you choose these products?”. Under this question, the five dimensions of similarity as hypothesized in H1.1 if Section 1.4 were listed alongside checkboxes.

Name: _____ 3

You are designing this product:

Hair dryer

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Hand drill ☐

Heat gun ☑

Space heater ☑

Glue gun ☑

Blender ☐

Why did you choose these products?

☐ Similar functions	☑ Similar functions	☑ Similar functions	☑ Similar functions	☐ Similar functions
☐ Similar form	☑ Similar form	☐ Similar form	☑ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☑ Similar energy flows	☑ Similar energy flows	☑ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☑ Similar material flows	☑ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):
	heats surface	heats area	heats Same in water	
	ergonomic shape		ergonomic shape	
	pretty much a			
	supercharge version			

Figure 5: A sample of the study instrument and raw data

An additional option of “Others” was also added. This was done so that if the participants perceive a dimension of similarity not already listed, they could check this option and list their perceived dimension in the space provided. The participants were allowed to pick one or more source products and were also allowed to pick one or more dimensions of similarity from the list for each source product. In addition, all the participants were required to briefly justify the dimensions of similarity that they picked. This salient feature of the instrument was incorporated to ensure that the selection was not random and some thought was actually put into the decision. For each target product presented, the corresponding source products were not ordered in any particular sequence.

3.1.4 Factorization of the Data

For the five target products, five such study instruments similar to the one shown in Figure 5, were developed (see Appendix A:). However, each of the fifty participants received only three target products. The assignment of the instruments to the participants was done on a rotating basis. The instruments were numbered 1 through 5, and the first five participants received the following numbers of the instruments: (1,2,3), (2,3,4), (3,4,5), (4,5,1), and (5,1,2), which was repeated for a total of ten times among the fifty participants. Thus, the total number of instruments used was 50 participants × 3 target products = 150 sheets. The total number of potential analogical references that this study was designed to detect is 50 participants × 3 target products × 5 source products × 5 dimensions = 3,750 total dimensions of similarity.

3.2 Data from the Pilot Study

In order to better understand the large amount of data explained above, the data was visually represented on the ordinate system explained above. For each target product, the five source products and the total number of selections made by the designers for each source product are shown in Figure 6 through Figure 10. The full set of data from the pilot study, from which the analyses and observations were made, is presented in Appendix B:.

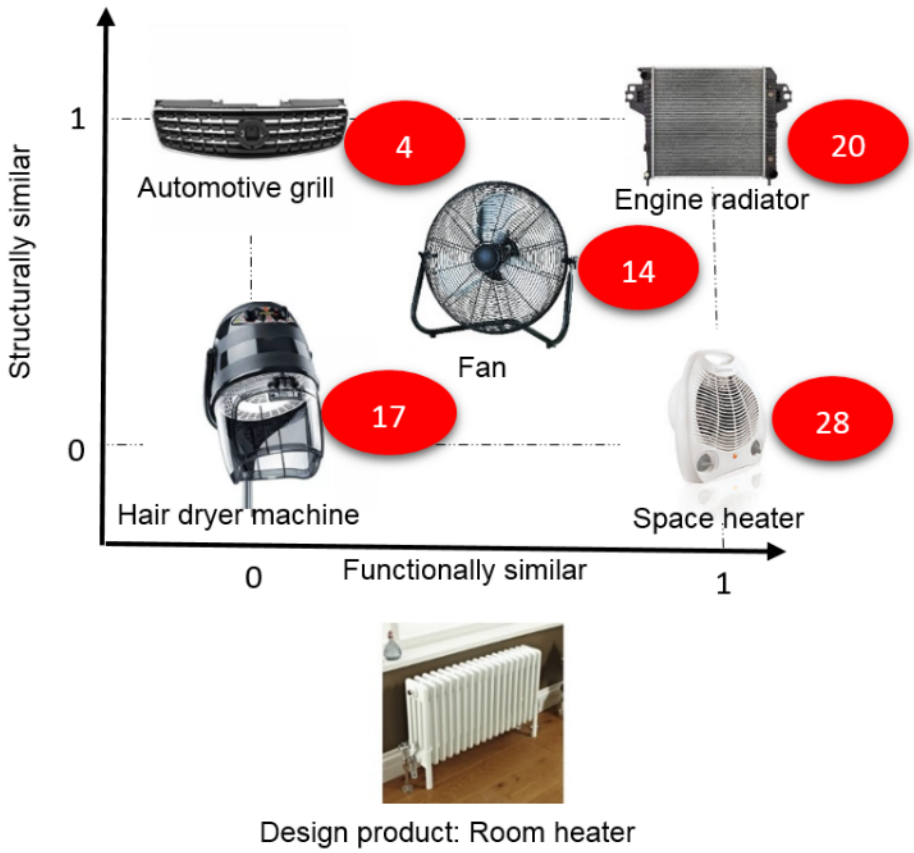


Figure 6: Selection of products for the Room Heater

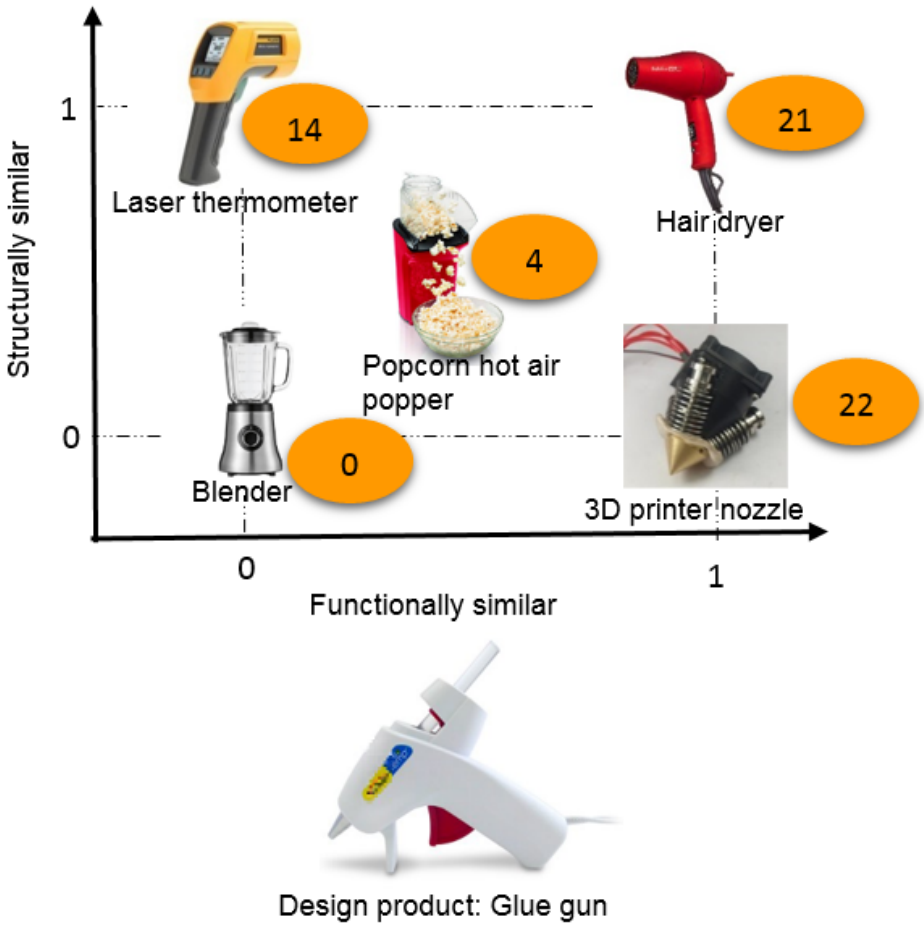


Figure 7: Selection of products for the Glue Gun

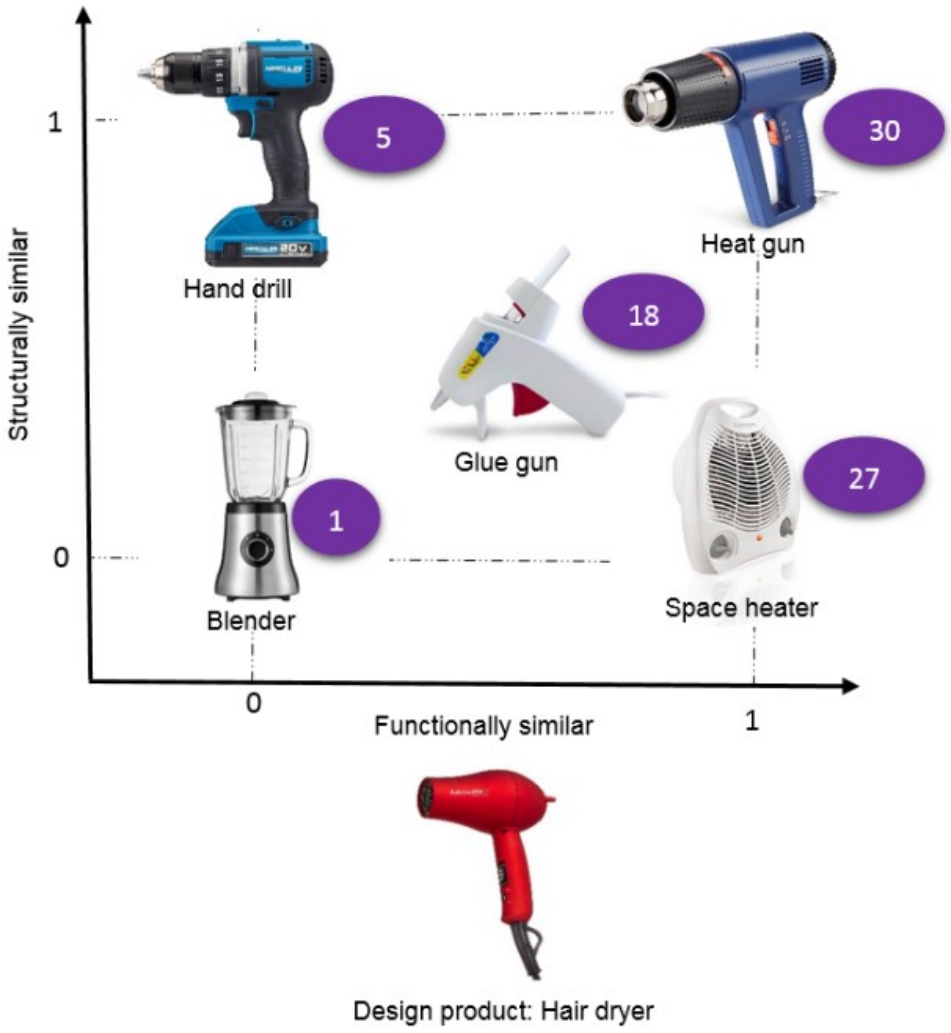


Figure 8: Selection for products for the Hair Dryer

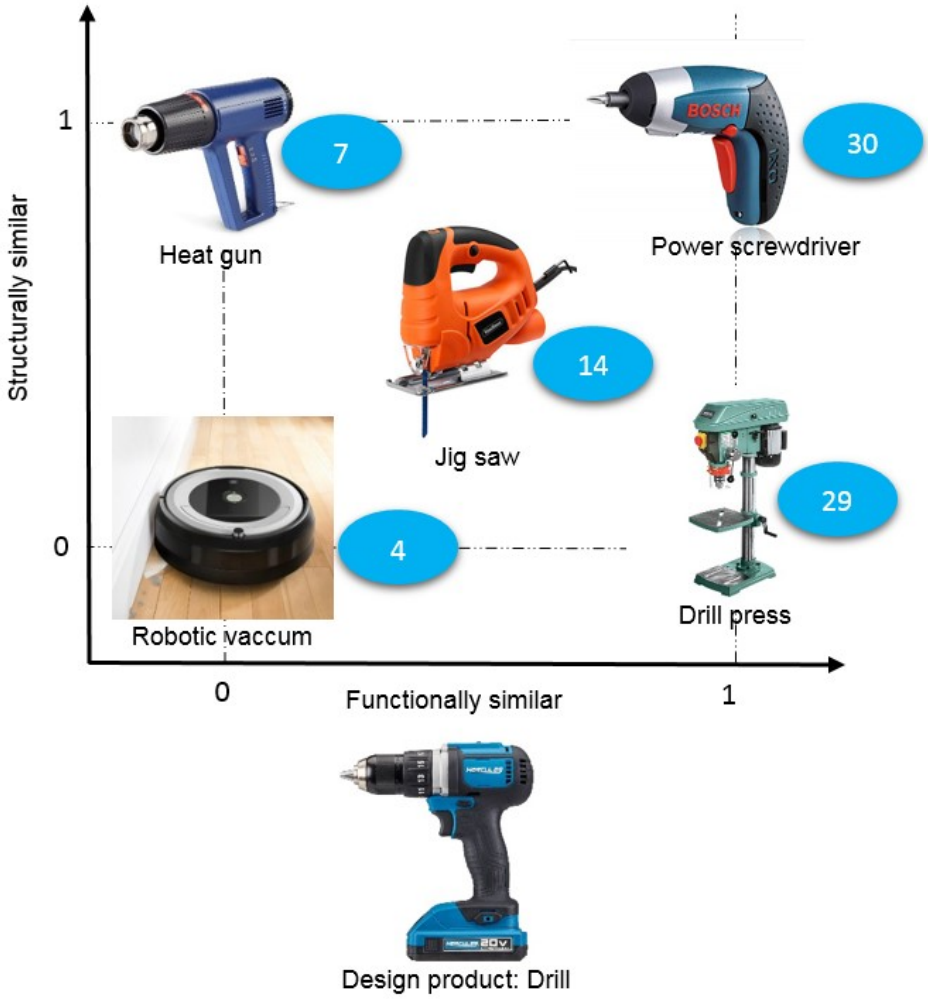


Figure 9: Selection for source products for the Drill

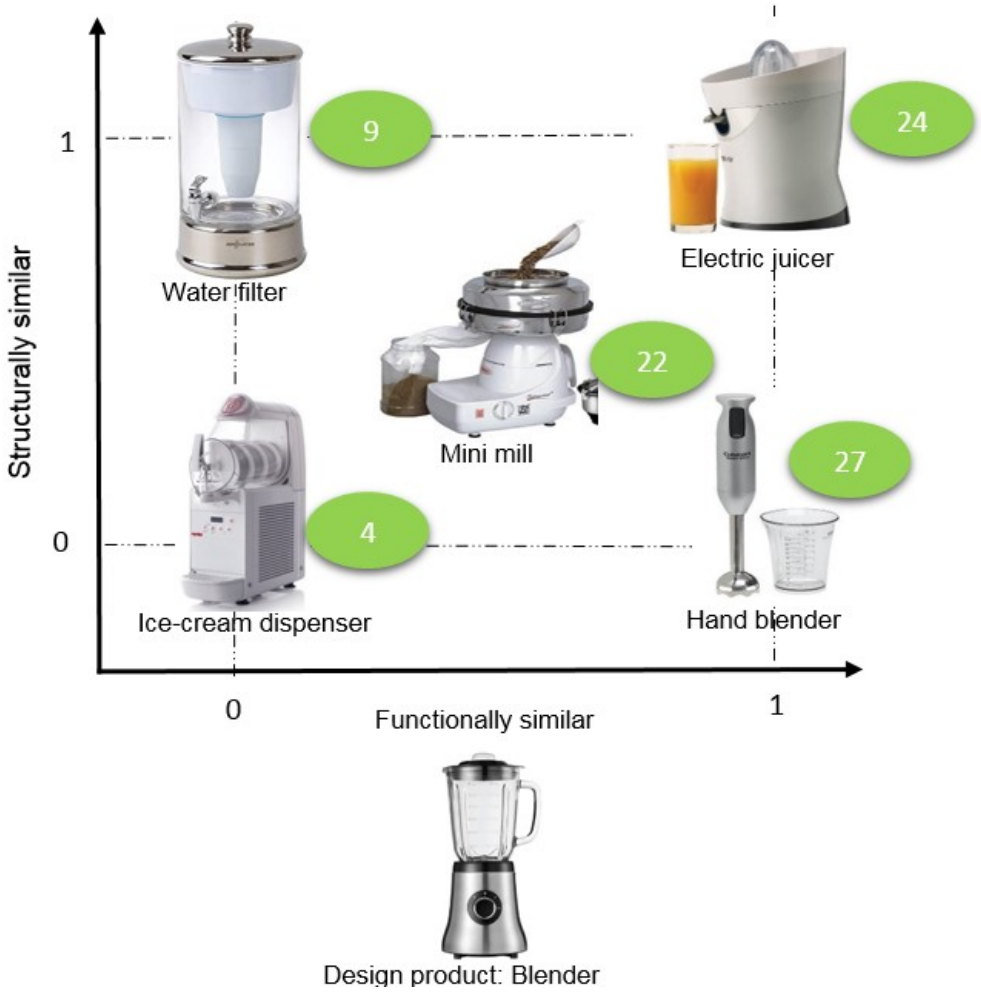


Figure 10: Selection of source products for the Blender

A quantitative analysis of the data was then performed. For each target product, the number of selections on each dimension was counted and summarized in Table 2. It is important to note that the entries in the table do not show the number of participants, but the number of selections made on the checkboxes presented in the study instruments.

Table 2: Summary of the data obtained from the pilot study

#	Target Prod.	Source Prod.	(x-y)	# Selections	Function	Form	Motion	Energy	Material	Others
1	Room Heater	Engine Radiator	(1,1)	20	12	18	16	14	7	0
		Space Heater	(1,0)	28	28	14	7	25	12	1
		Fan	(0.5, 0.5)	14	10	1	3	5	4	0
		Automotive Grill	(0,1)	4	2	3	2	2	0	0
		Hair Dryer m/c	(0,0)	17	13	2	2	14	8	0
2	Glue Gun	Hair Dryer	(1,1)	21	6	15	4	15	0	0
		3D printer nozzle	(1,0)	22	15	10	5	12	18	0
		Popcorn popper	(0.5, 0.5)	4	1	0	0	3	1	0
		Laser thermometer	(0,1)	14	3	9	4	5	2	3
		Blender	(0,0)	0	0	0	0	0	0	0
3	Hair Dryer	Heat Gun	(1,1)	30	23	27	16	26	18	0
		Space Heater	(1,0)	27	22	5	3	24	18	1
		Glue Gun	(0.5, 0.5)	18	5	12	2	13	0	0
		Hand Drill	(0,1)	5	1	3	0	3	0	1
		Blender	(0,0)	1	0	0	1	1	0	0
4	Drill	Power Screwdriver	(1,1)	30	26	29	27	23	13	0

#	Target Prod.	Source Prod.	(x-y)	# Selections	Function	Form	Motion	Energy	Material	Others
		Drill Press	(1,0)	29	29	1	23	18	8	1
		Jig Saw	(0.5, 0.5)	14	3	4	6	11	6	0
		Heat Gun	(0,1)	7	1	7	2	2	1	0
		Robotic vacuum	(0,0)	4	1	0	0	2	1	0
	Blender	Electric Juicer	(1,1)	24	22	8	14	14	10	1
		Hand Blender	(1,0)	27	27	4	23	15	16	1
		Mini Mill	(0.5, 0.5)	22	19	5	17	13	5	0
		Water Filter	(0,1)	9	2	3	3	3	2	1
5		Ice-cream Disp.	(0,0)	5	2	0	2	3	0	0

3.3 Data Analysis and Observations

The summary of the selections of source products for each target product was plotted on a line plot as shown in Figure 11. Data for the five target products is represented by a different font of trend line. Points on the horizontal axis represent the (x, y) number designations of the source products. The vertical axis represents the total number of times a source product was selected.

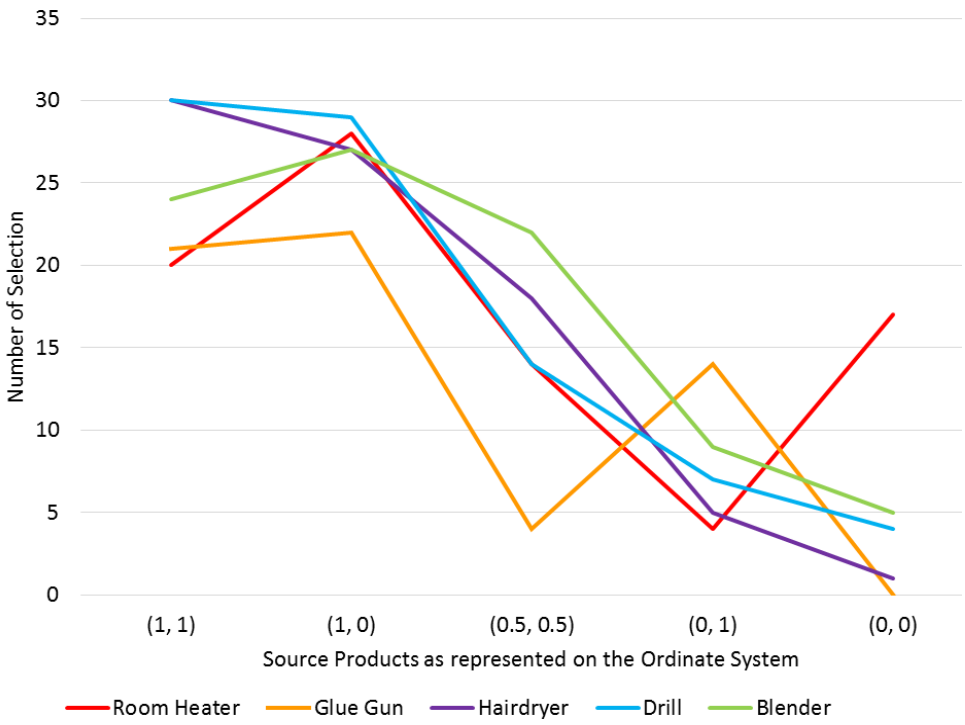


Figure 11: Source product selections for all target products

It is observed that for all target products, the highest frequency of selection occurred for source products that either had both functional and structural similarity with the target (designation: 1,1) or had functional but not structural similarity (designation: 1,0). The preference for the source products that had both minimal functional and minimal structural similarity, i.e., (0,0), was the lowest for all target products, with the exception of the room heater. In between these two extremes, the selection reduce almost monotonically from (1,0) to (0.5, 0.5) to (0,1). Compared to (1,1) or (1,0), lower preference was noted for source products with designation (0.5, 0.5). The participants also showed some preference for the source products that were structurally but not-functionally similar (designation: 0,1). However, across all products, the preference for mere structural similarity was lower than both the preference for just functional similarity (1,0) and the preference for functional and structural similarity (1,1). Only in the case of the target product glue gun the participants showed more preference for partial structural and functional similarity than for just structural similarity. In the following sections, more detailed observations for each target product is presented.

3.3.1 Preference Trends for the Room Heater

As seen in Figure 12, the x-axis represents each of the five dimensions of similarity and the y-axis the number of times each of the dimensions was selected. The most preferred source product was the space heater (1,0), followed by the engine radiator (1,1), hair dryer machine (0,0), fan (0.5, 0.5) and finally the automotive grill (1,0). The responses in the checkboxes show that the products with function similarity of more than 0.5 were selected mainly because of their function similarity.

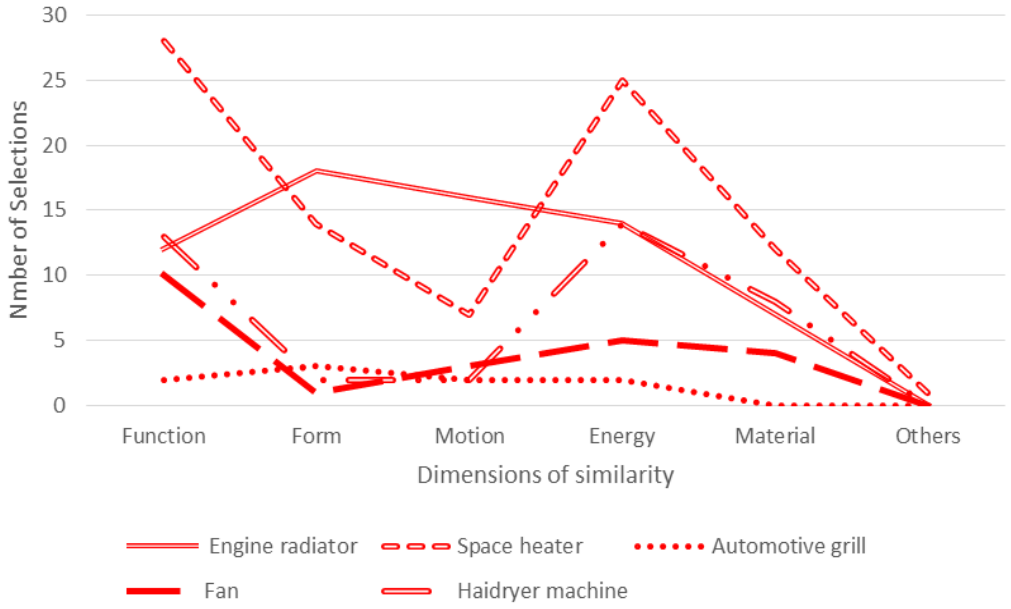


Figure 12: Preference trends for the Room Heater

The secondary dimensions of similarity were energy and material flows. This may indicate that functional similarity was perceived to be associated with energy and material flows. For the engine radiator, form was more dominant than function, energy, motion, and material. This observation is also counter-intuitive and has been explained as an anomaly in Section 3.5. In the design, the hair drying machine was intended to possess minimal function and structure similarity with the room heater (0,0) but was selected by participants for function, energy and material similarity. This is another anomaly that could indicate a flaw in the design of study, and is explained in section 3.5. Participants showed low preference for automotive grill that was similar in form, implying that a product that has form-similarity but offers no function-similarity was considered less useful for analogy.

3.3.2 Preference Trends for the Glue Gun

The selection trends for the glue gun are shown in Figure 13. The most preferred source product was the 3D printer nozzle (1,0), followed by hair dryer (1,1), laser thermometer (0,1), popcorn hot air popper (0.5, 0.5) and the blender (0,0), which received no preference at all. Based on checkbox selection data, for the products with function similarity of 1, functional similarity was used the most frequently. However, material and form were frequently selected for the 3D printer nozzle, compared to the energy and form dimensions for the hair dryer. This behavior again implies that functional similarity is strongly associated with material and energy flows. Also, even though 3D printer nozzle and hairdryer have different levels of form similarity, little difference was observed in the participant selection of form for these two products. For the hot air popper that has some form and functional similarity, energy was the only dominant dimension. For the laser thermometer, structural similarity had weaker association than function, energy, material, and motion. However, the handwritten comments suggest that the designers detected motion similarity between glue gun and the laser thermometer based on the motion required to operate the trigger.

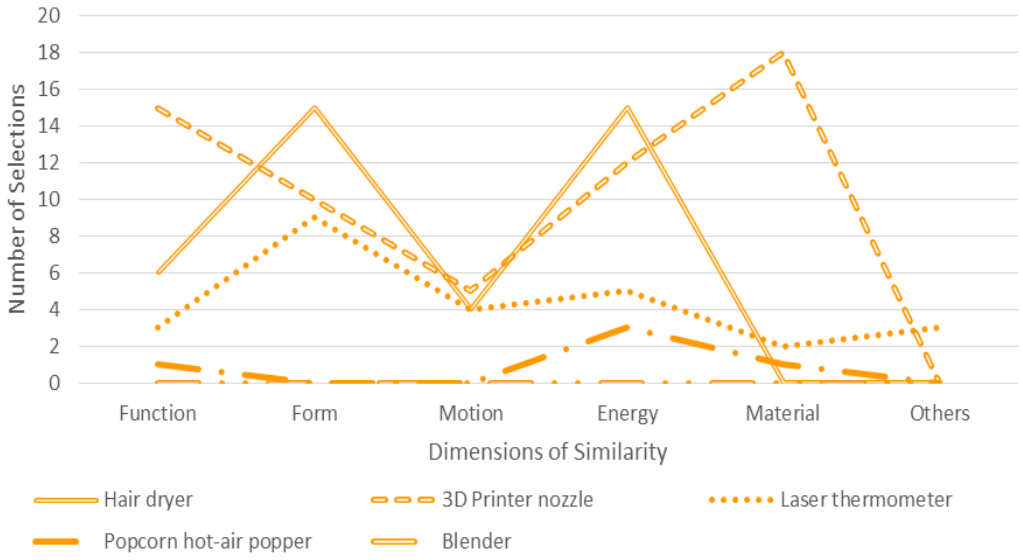


Figure 13: Preference trends for the Glue Gun

3.3.3 Preference Trends for the Hairdryer

As seen in Figure 14, the x-axis represents each of the five dimensions of similarity and the y axis the number of times each of the dimension was selected. The most preferred source product was the heat gun (1,1), followed by space heater (1,0), glue gun (0.5,0.5),

hand drill (0,1) and blender (0,0). For the products with the functional similarity of 1, there was almost equal preference for the function dimension of both products. This pattern was also repeated for the energy and material dimension. This implies that the designers perceive these products to be almost exactly similar on these three dimensions.

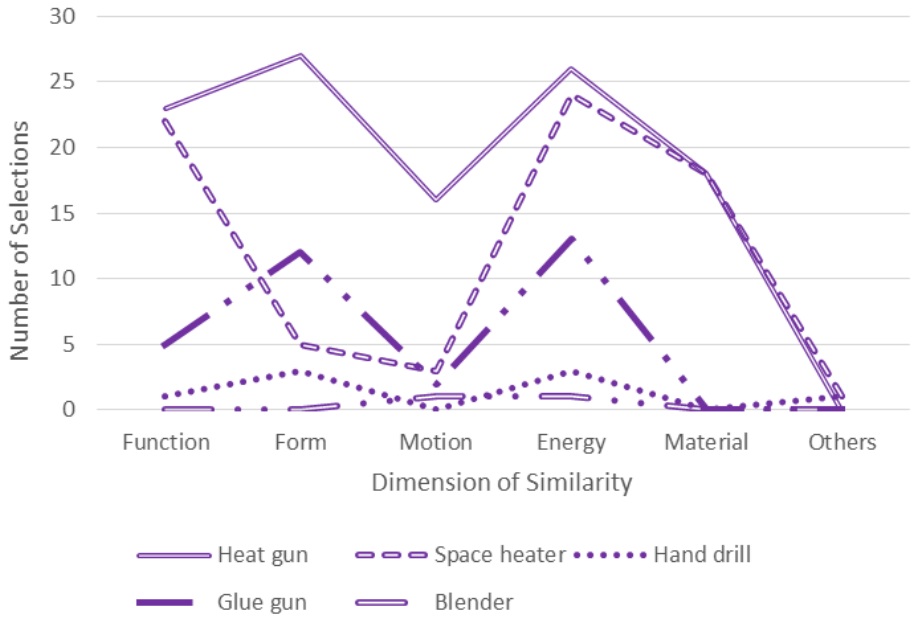


Figure 14: Preference trends for the Hairdryer

The product with the (0.5, 0.5) designation was perceived less similar along the function, motion, and material flow dimensions than it was in the form and energy flow dimensions. This implies that a difference in material output also results in the product being viewed as less functionally similar. For the glue gun, highest similarity was perceived along the energy dimension, followed by form, function, and motion. No preference was shown for material flow similarity. For the hand drill, highest similarity perceived was tied along the form and energy dimensions, followed by function dimension, and no preference for motion and material. For the blender, only one preference was received which was along the motion and energy dimension.

3.3.4 Preference Trends for the Drill

Figure 15 presents the selection data for the various analogy dimensions for the drill. The most preferred source product was the power screwdriver (1, 1), followed by drill press (1, 0), jig saw (0.5, 0.5), heat gun (1,0), and the robotic vacuum (0,0).

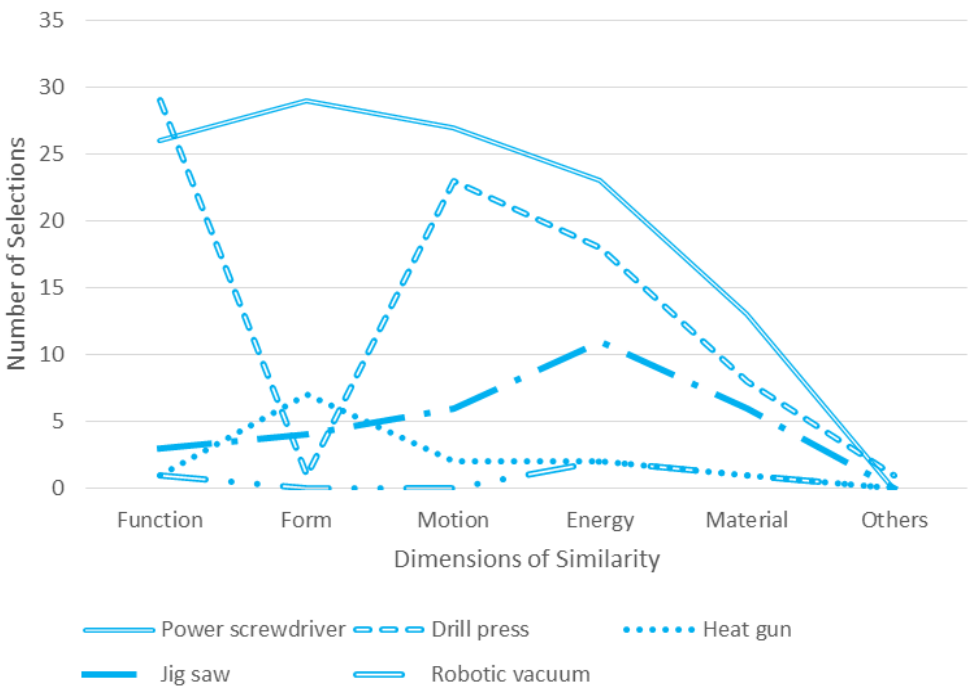


Figure 15: Preference trends for the Drill

The products with a functional similarity of 1 were mainly selected for function similarity, followed by motion, energy, and material similarity, which indicates the designers' preference for similarity on these multiple dimensions, but mainly function. Designers showed little preference for the product that only had form similarity. However, high preference was shown for the form dimension for the product with high function and form similarity. For the product with (0.5, 0.5) designation, the energy dimension was the most preferred, followed by material and motion dimension. For the drill, the function is very closely associated with the motion of the source product and the energy required for it.

3.3.5 Preference Trends for the Blender

Figure 16 shows the selection data for the dimensions, for the blender target product. The most preferred source product was the hand blender (1,0), followed by electric juicer (1,1), mini mill (0.5, 0.5), water filter (0,1), and ice cream dispenser (0,0). For the hand blender, electric juicer, and the mini mill, the highest similarity was perceived along the function dimension, which, once again, indicates that products that have a functional similarity of 0.5 or higher with the target are selected mainly for their functional similarity. For all of these three products, the second choice of dimension was motion,

and the third was either material or energy flow similarity. This indicates that designers also prioritize product similarity based on these dimensions. Note that motions are closely related to functions, but energy flows are not, since the same functions could be obtained using different energy flows.

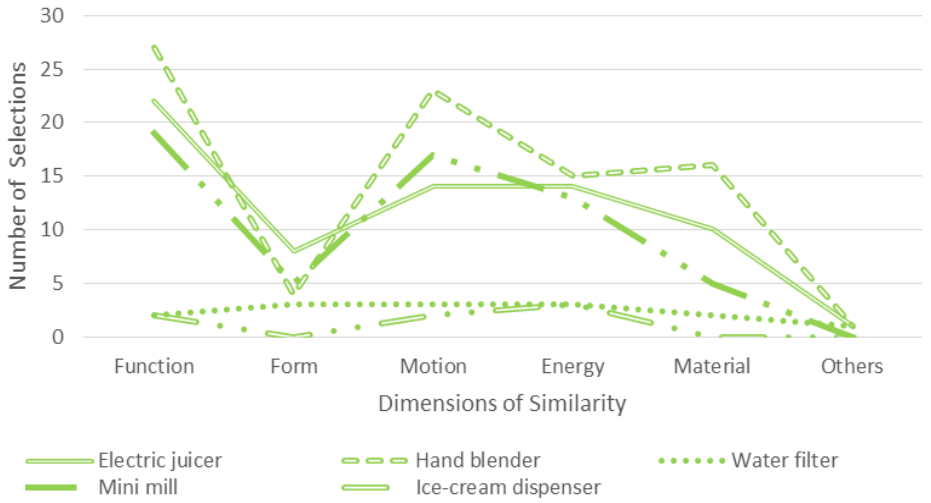


Figure 16: Preference trends for the Blender

For the water filter, which received only nine selections, highest similarity was the same for the form, motion, and energy dimensions, followed by a tie between the function and material dimensions. For the ice cream dispenser, which was selected only four times, the highest similarity was perceived along the energy dimension, followed by a tie between function and motion and no preference for material and form. Thus, it appears that products that have similarity with the target in form but not in function are selected for their form-similarity, although showing a weaker preference for form-similarity than function-similarity.

3.3.6 Overall Trends in Dimension of Similarity

When the dimensions of similarity indicated in the check boxes and the hand-written justifications were pooled for all five target products, the dimension of function similarity was the most preferred source of analogy, followed closely by the energy dimension. Form and motion similarity dimensions were almost equally preferred. Material dimension was the least preferred. These trends are reflected in Table 3.

Table 3: Overall trends in Dimensions of Similarity

Dimension of Similarity	Function	Form	Motion	Energy flow	Material flow	Others
Total count	273	180	182	266	150	10

3.4 Inferences and Answers to the RQs from the Pilot Study

From the observations listed above, some inferences can be drawn about the dimensions of product similarity along which the designers perceived similarity.

1. First, **to answer RQ-1**, the data suggests that designers recognize products as source of analogy during solution search based on multiple dimensions, including function, form, motions, energy flows, material flows, and several other factors. This is in agreement with the existing literature. However, the data did not conclusively indicate that all analogical inference is limited to these six dimensions only. Thus, **hypothesis H1.1** is but not sufficiently supported.
2. **To answer RQ-2**, the data shows that when designers are asked to use multiple source products from which to draw analogy, they tend to select the products with a strong functional or functional-and-structural similarity, which is collectively given by the (1,1) and (1,0) products. These two dimensions overwhelmingly dominate over the other dimensions for all products, as seen in Table 3. This inference is in agreement with prior research in the areas of shape similarity and Design by Analogy.
3. The data also suggests that when presented with products with high functional similarity with the target product (0.5 or higher), designers choose those source products because of that functional similarity. This observation implies that functional similarity, when present, are easily detectable and dominates designers' decisions. Even when products with both function and form-similarity (i.e., the 1,1 products) are selected, the handwritten justifications indicate that the designers chose the product for functional similarity more frequently than for the form-similarity. Thus, it appears that designers detect functional similarity more easily or naturally than the other dimensions.
4. When perceiving analogy along the function dimension, the participants almost always perceive similarity along the energy dimension. However, the perception of similarity along function is also sometimes paired with the motion and material dimensions. Hence, it is possible that the energy, motion, and material dimensions are confounded with the function dimension.

3.5 Explanation of Anomalies and Lessons Learned

This section makes an attempt at explaining the anomalies mentioned above. It can be seen in Figure 6 that for the target product room heater, the number of selections for the source product with (0,0) designation (hair drying machine) was higher than that for the (0.5, 0.5) product (fan). When the dimensions of similarity were analyzed, it was found that the participants perceived similarity in the energy, function and material dimension between the room heater and the hair drying machine. In hindsight, the hair drying machine was a poor selection for the (0,0) position for the target product room heater.

It was found that the naming convention can also skew the perception of similarity. In the case of the target product room heater, a source product named “space heater”, which had functional similarity but not form similarity with the target (1,0), received more selections than the engine radiator, which had both of those similarities (1,1). It would be interesting to see how the selections are impacted if the target product was called “room radiator”, making it phonetically similar to the “engine radiator”.

The selection of the space heater over the engine radiator could have also been influenced by the product’s application area and market segmentation. Both the room heater and the space heater are used to heat indoor air and are competing options for the same market segment or customer need. The engine radiator, while similar to the room heater in function and form, operates in a significantly different environment and meets a different need of the customer. Future studies will be designed with these possibilities in mind.

In general, it was felt during data analysis that providing the check boxes for indicating the product similarities could potentially skew the data. While a check-box based design of the instrument makes data analysis faster and more unambiguous, it may distort the data by either unnecessarily prompting the participant to check a box or by forcing them to converge the type of similarity used in the analogy to one of the five check boxes, instead of expressing the true nature of the similarity used. Further, since the participant pool comprised of undergraduate engineering students are typically not trained in graduate level design theory and methods, it is possible that their interpretation of the five dimensions deviated from the definitions presented in Section 1.3, which would further skew the results. In the main study, therefore, the check box-based design should be replaced with a more open design that is better capable of capturing the similarities used by the designers even if that calls for more laborious data analysis.

The next chapter describes the main study, which was informed by the findings and lessons learned from the pilot study described above, and accordingly included a slightly different method of data collection.

Chapter 4: The Main Study and Its Findings

The main study was the second of the two studies conducted within this research. It's design was similar to that of the pilot study and was modified based on the lessons learned from it, in the following ways.

1. In the study instrument, the rationale for selecting the source products as potential source of analogy was collected by asking the designers (voluntary participants) to write their rational in plain English instead of the check boxes, for reasons explained in the previous section. This allowed for a more natural dissemination of the rationale, although it called for more laborious data analysis.
2. The main study used eight dimensions of product similarity based on the findings of the pilot study, as stated in hypothesis H1.2 in Section 1.4. These dimensions are those defined in Section 1.3: **function (F), working principle (WP), behavior (B), material flow (M), energy flow (E), structure (S), purpose (P), and human interaction (HI)**.
3. To instill rigor in data encoding and analysis, three independent coders were used to ensure that the source-target pairs in the five variants of the study instrument did not accidentally create a bias for or against any one dimension, and two independent coders were used in encoding the data. A rigorous method was developed for reconciliating their differences.

These details are further presented below.

4.1 Design of the Main Study

4.1.1 Participants and Training

Fifty undergraduate mechanical engineering students (41 males, 9 females) enrolled in a junior-level Design of Machine Elements course at Florida Institute of Technology in Fall 2019 served as voluntary participants. As with the pilot study, the experiment protocol was approved by the Institutional Review Board of the university. None of the fifty participants of the pilot study was repeated in the main study. The volunteers were rewarded with extra credits in the course for their participation. During collecting the completed study instruments, the sheets were assigned serial numbers in the order of receipt such that the tabs containing the participants' names could be removed from the instruments prior to data analysis, so that their identities were masked from the data encoders. The names were collected so that the instructor of the course could give the

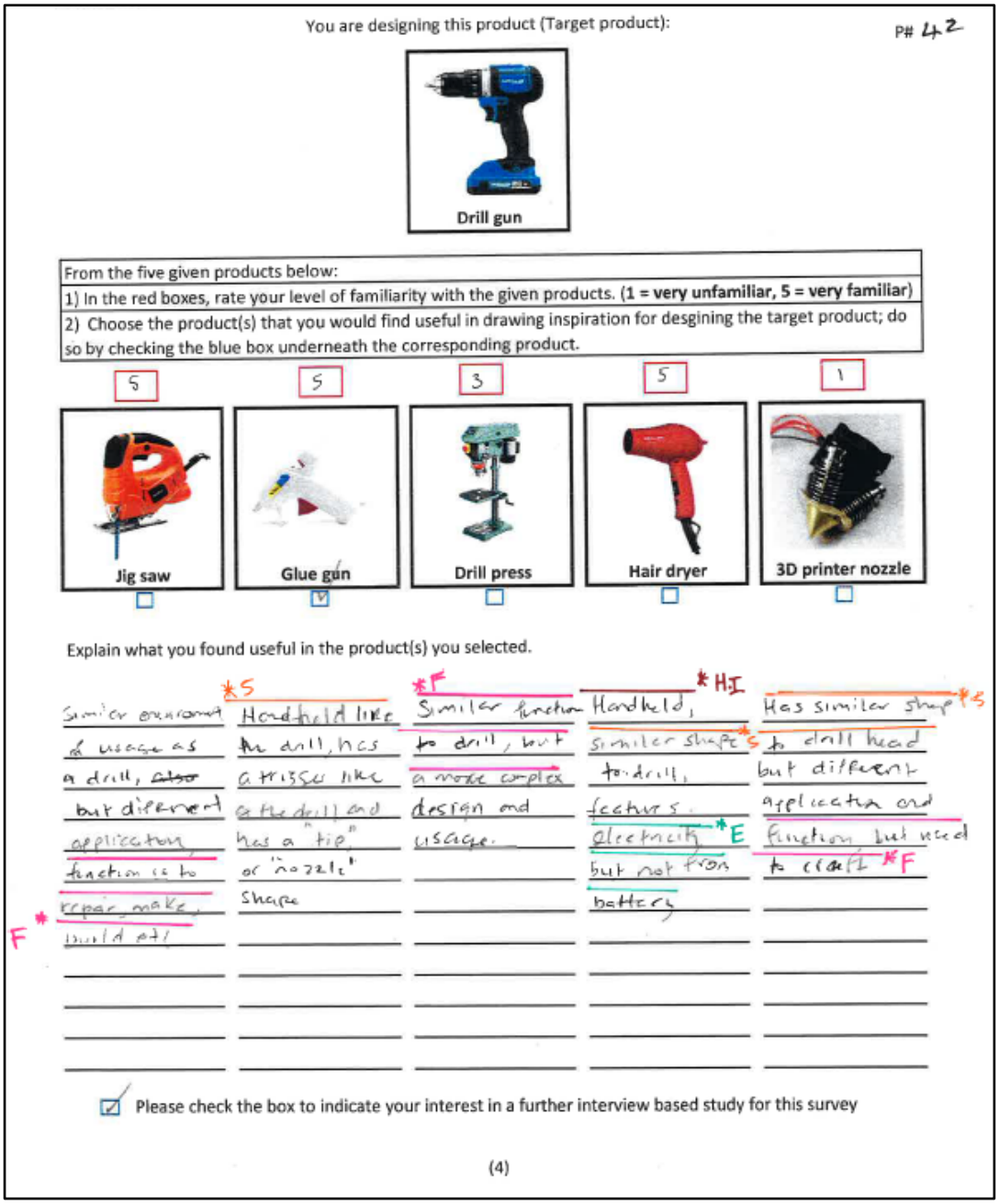
extra credits to only those students who participated. Prior to data collection, the participants were trained in the same manner as the pilot study (see Section 3.1.1). A time limit of 50 minutes was set for completing the two instruments, based on the length of the class period where the study was conducted. However, the time used to complete the instruments ranged between 7-23 minutes.

4.1.2 Design of the Study Instrument

Figure 17 shows one of the five variants of the research instrument used in the main study. All other variants can be found in Appendix C:. A comparison with Figure 5 will reveal that this study instrument is similar to the one used in the pilot study, with the following differences.

1. The participant's name goes over the dotted line at the top (not visible in the figure), so that it could be removed after grades were assigned in order to protect their identity. The P-number at the top-right corner is used to uniquely identify each sheet.
2. The five red boxes above the source product images are used to collect the participant's level of familiarity with each product using a five-point Likert scale (1 = very unfamiliar, 5 = very familiar), so that the designer's confidence in the detection of the source products could be considered during data analysis.
3. The instructions below the target product ask the participant to indicate their familiarity with the source products using the red boxes, and to identify the source products that they considered useful for analogy using the blue check boxes below the source product images.
4. The ruled area in the lower half of the sheet is space for the participants to write in plain English their rationale for selecting each source product as a useful source of analogy.

As mentioned earlier, the last point mentioned above is a major difference between the pilot and the main studies. In the pilot study, participants were asked to indicate the dimensions they considered similar between the source and the target products by checking boxes against the dimension names that were provided in the instrument. This method produces data that is easier to analyze because it is unambiguous (checked or unchecked), but relied heavily on the participants' interpretation of the dimensions. Without sufficient training in design methodologies, the participants' ability to distinguish between these terms was unreliable. In the main study, the data about these similarities is collected in plain English text, which is then used to identify the similarity dimensions recognized by the participants through encoding and analysis later, as explained in Section 4.2.2.


You are designing this product (Target product):

P# 42

Drill gun

From the five given products below:

1) In the red boxes, rate your level of familiarity with the given products. (**1 = very unfamiliar, 5 = very familiar**)

2) Choose the product(s) that you would find useful in drawing inspiration for desgining the target product; do so by checking the blue box underneath the corresponding product.

5	5	3	5	1
Jig saw	Glue gun	Drill press	Hair dryer	3D printer nozzle
☐	☑	☐	☐	☐

Explain what you found useful in the product(s) you selected.

Similar environment of usage as a drill, but different application, function is to repair, make, build etc	*S Handheld like the drill, has a trigger like a the drill and has a "tip" or "nozzle" shape	*F Similar function to drill, but a more complex design and usage.	*HI Handheld, similar shape*S to drill, features *E electricity but not from battery	Has similar shape*S to drill head but different application and function but need to craft *F

☑ Please check the box to indicate your interest in a further interview based study for this survey

(4)

Figure 17: Research instrument for the main study, with manual encoding of the plain-text rationale data showing in colored underlines and tags

4.1.3 Selection of Target and Source Products

For the main study, five different variants of the instrument were used, with the following five products listed as the target: electric kettle, glue gun, hairdryer, drill gun, and kitchen blender. Each instrument had five source products, thus producing 5 × 5 = 25 possible source-target pairs. These source products were drawn from a set of fourteen products, which included the five target products and nine other products. In no case was a target product repeated as a source product in another instrument. The mapping between source and target products in the five instrument variants is shown in Table 4.

Table 4: Mapping between target and source products

Target product	**Source product options in the instrument**
Electric kettle	3D printer nozzle, glue gun, drill press, electric juicer, robotic vacuum
Glue gun	Fan, 3D printer nozzle, hairdryer, kitchen blender, electric kettle
Hairdryer	Space heater, 3D printer nozzle, robotic vacuum, glue gun, drill gun
Drill gun	Jig saw, glue gun, drill press, hairdryer, 3D printer nozzle
Kitchen blender	3D printer nozzle, hand blender, space heater, fan, power screw- driver

In each variant, one source product was intentionally chosen to have little or no similarity with the target. For example, in Figure 17, the 3D printer nozzle is not similar to the target (drill gun) by any dimension other than input energy (electrical). The remaining source products were selected such that they offered a mix of different dimensions of similarity with the target within the specific sheet and collectively between the five variants of the instrument. The objective of this distribution of source products over the target products was to avoid biasing the data for or against a specific dimension. For example, if the source products were carelessly chosen so that a majority of them was similar to the target product in terms of, say, human interaction but only a few were similar by function, then the data could suggest that human interaction was more dominant than function in the formation of analogical reference, regardless of the truth. To avoid such bias, it was necessary to know the dimensions by which each source-target pair was

similar and to carefully create an even distribution of the dimensional similarities over the instruments.

For this purpose, three different coders reviewed the source-target pairs proposed in the five instrument variants (see Table 4) and rated each pair (total 25 pairs) for their similarity by each dimension. For example, Table 5 shows the coders' reconciled assessment of similarity between the target (drill gun) and the five source products shown in Table 4, against each of the eight dimensions (F = function, WP = working principle, B = behavior, P = purpose, S = structure, M = material flow, HI = human interaction, and E = energy flow). The H-M-L keywords in that table stand for high, medium, and low similarity. For example, the letter L in the bottom of the F-column implies that the coders felt that the drill gun has low similarity with the printer nozzle along the dimension of function.

Table 5: Hypothesized similarity between sources and target

Target	**Source**	**F**	**WP**	**B**	**P**	**S**	**M**	**HI**	**E**
Drill gun	Jig saw	H	H	H	M	M	H	H	H
	Glue gun	M	L	L	M	H	L	M	M
	Drill press	H	H	H	H	H	H	M	H
	Hairdryer	L	L	M	L	H	L	M	M
	3D printer nozzle	L	L	L	L	L	L	L	H

Such a table was developed for each instrument variant. When the coding for any cell in a table varied between the coders, the coders met to review the ratings for all the cells and reconciled their differences so that the relative ratings of high, medium, and low similarities remained consistent among the source-target pairs. The full set of tables for each instrument and for each coder, along with the table showing the reconciled H-M-L ratings is available in Appendix D:. Based on this analysis, the instruments were adjusted to offer an unbiased distribution of source-target pairings, collectively between them.

4.1.4 Factorization of the Data

As with the pilot study, each instrument presented one target product and five source products, creating a total 25 source-target pairs per instrument. Each participant received two different variants of the instrument. The instruments were numbered 1-5 and distributed among the participants so that each pair, i.e., (1,2), (2,3), (3,4), (4,5), and (5,1), occurred ten times each between the fifty participants. While the dimensions of similarity

were not presented as check boxes, there were eight of them. Thus, the study was designed to collect 50 participants × 2 instruments × 5 source-target pairs × 8 possible dimensions of similarity = 4,000 possible similarity instances.

4.2 Data Analysis

A sample of the raw data collected from the study is shown in Figure 17. The following protocol was used to filter, encode, and analyze the data.

4.2.1 Data Quality and Encoding Protocol

The total number of completed sheets was 50 participants × 2 instruments each = 100. The sheets were examined to eliminate invalid data resulting from incomplete or ambiguous responses. In all, 39 sheets were discarded for the following reasons:

- **Misunderstood instructions**: In some cases, the source products were selected based on if they could be used to manufacture or assemble the target product, or their parts could be reused to make the target product.
- **Ambiguous response**: The dimension of similarity used as the basis of selecting a source product was unclear from the written response. Examples include: "the design is similar", "They are the same in a different way", and "The product seems to be the same but not much."

The 61 accepted data sheets were analyzed independently by two coders. Each coder reviewed the plain-text comments and labelled (underlined or tagged) the places within the text where evidence of each of the dimensions of similarity being used to select source products was found, as shown in Figure 17, with the colored underlining of the text and their initials. Later, these findings were translated and summarized in the matrix form shown in Table 6. For example, the first row shows that the specific (P42) participant provided evidence that she considered the drill gun (target) and the jig saw (source) to be similar in terms of function (F) and structure (S), as implied by the 1's in the corresponding cells. A zero in a cell implies that the participant did not consider the source and the target to be similar by that dimension.

Table 6: Data encoding matrix example for data P42

Target		**F**	**WP**	**B**	**P**	**S**	**M**	**HI**	**E**
Drill gun	Jig saw	1	0	0	0	1	0	0	0
	Glue gun	0	0	0	0	1	0	1	0
	Drill press	1	0	0	0	0	0	0	0

Target		F	WP	B	P	S	M	HI	E
	Hairdryer	0	0	0	0	1	0	1	1
	3D printer nozzle	1	0	0	0	1	0	0	0

One such table was produced for each of the 61 sheets. Since each sheet contains five product-pairs (1 target × 5 sources), and each pair is analyzed against eight dimensions of similarity in the table, the total number of similarities analyzed was 61 sheets × 5 pairs × 8 dimensions = 2,440 cells in these tables.

4.2.2 Reconciliation between the Coders

Data from the 61 sheets mentioned above was encoded into the 2,440 cells, as explained above, by the two coders independently. Upon comparing their encodings, three possibilities emerged:

1. **0-agree**: Both coders agree that a cell should contain a 0, i.e., the participant did not detect a similarity between the source-target pair in terms of the dimension indicated by the column header of that cell.
2. **1-agree**: Both coders agree that a cell should contain a 1, i.e., the participant did detect a similarity between the source-target pair in terms of the dimension.
3. **Disagree**: One of the coders assigned a 0, while the other assigned a 1 in a cell, suggesting that they could not agree if the participant detected a similarity.

Figure 18 shows the distribution among these three categories prior to reconciling the differences between the coders. The high proportion of 0-agrees (85%) is expected. It implies that the encoding matrices such as Table 6 were sparsely populated, which happened because the source products were so chosen that each offered similarity with the target only by a few dimensions, instead of all of them offering all types of similarities. This sparseness was intentionally designed so that the detections of similarity could be attributed to one or a few dimensions instead of being confounded by many dimensions.

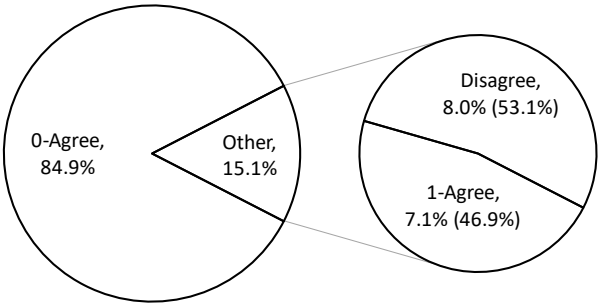


Figure 18: Data distribution prior to reconciliation

Out of the remaining 15% of the data, which represents all cells where at least one or both designers wrote a 1, 47% was in agreement (1-agree) and 53% was in disagreement. Figure 19 and Figure 20 show the distribution of the dimensions among these two sets.

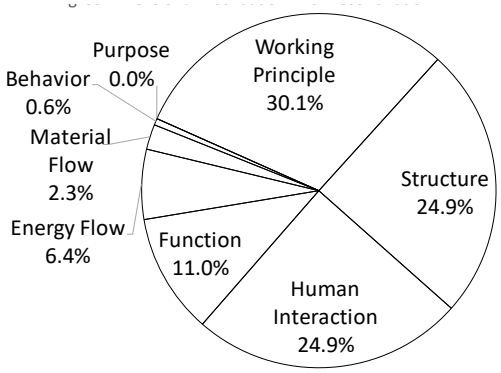


Figure 19: Distribution of dimensions within the 1-agree set prior to reconciliation

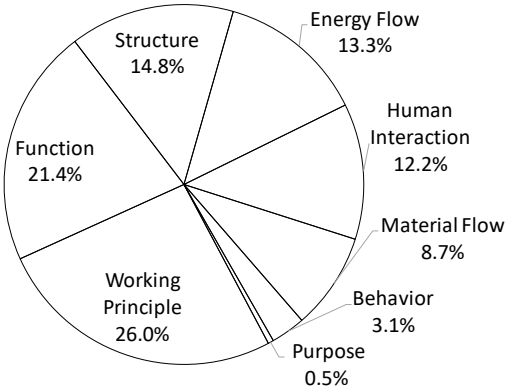


Figure 20: Distribution of dimensions within the disagree set prior to reconciliation

As seen in Figure 19, more than 75% of the 1-agreements come from similarities in working principle, human interaction, and structure, while functional similarities account for only 11% of 1-agreements. However, this distribution may be distorted because of the significant amount of disagreements (8% of total, 53% of cells containing 1). Among the disagreements (Figure 20), the largest contributors are working principle, function, and structure, which is expected since function and working principle are relatively easy to confuse while coding, especially when the plain-text rationale does not clearly indicate the dimension used by the participant.

The disagreements in the 8% of the data (196 cells out of the total 2,440) were reconciled by the coders by jointly reviewing each case and comparing them against the definitions of the analogy dimensions presented in Section 1.3, until all disagreements were resolved. The main sources of differences were found to be the following:

- In some instances, the plain-English text from the participant fit the definition of both function and working principle, causing the coders rate them differently. For reconciliation, the coders decided to code these cases under both function and working principle.
- In some other cases, ambiguity rose between human interaction and structure. For example, a text such as “have a similar handle” would fit both definitions. To reconcile these cases, the raters agreed to code all structural similarities that refer to ergonomics such as handles and triggers under only human interaction-based similarity.
- In very few instances, purpose and function were mixed up due to vague responses. Careful revision of these cases against the definitions led to agreement between the coders.
- Finally, plain-text data that referred to internal parts such as motors and blades were sometime categorized as either working principle or structure. To address this anomaly, the coders carefully reviewed each instance to determine if the context of the data leaned more toward one dimension or the other. Data that were too ambiguous to sort out were discarded.

The data was reconciled until no disagreements remained, which gave rise to the final, reconciled data, as shown next.

4.2.3 Distribution of Analogy Dimensions in the Data

Post reconciliation, only the 0-agree and 1-agree sets of data remain, and Figure 21 shows their distribution. 12.4% of the full data (2,440 cells) contain a 1, which implies that the encoding matrices were 12.4% full.

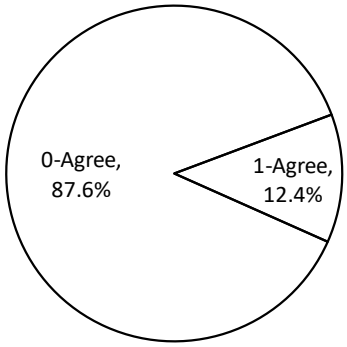


Figure 21: Data distribution, post-reconciliation

Figure 22 shows the distribution of the analogy dimensions within the 12.4% of cells where similarity was detected. As seen here, 86% of the agreements come from only four dimensions: working principle, structure, human interaction, and function. A comparison between Figure 19 and Figure 22 reveals that the reconciliation did not affect the order in which the dominant dimensions contributed to the detection of similarity.

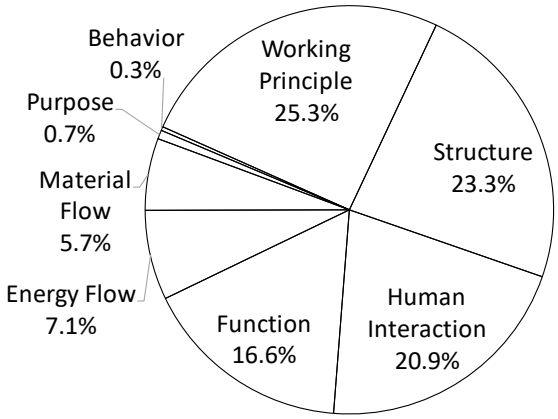


Figure 22: Distribution of analogy dimensions within the 1-agree set, post-reconciliation

4.2.4 Average Number of Dimensions Used by Participants

Using the post-reconciliation data, the average number of dimensions per source-target pair used by all participants came out to be 1.76 out of the 8 proposed dimensions. This mean was calculated using the source-target pairs in which at least one dimension was identified by the participant. Further, in Table 7, the number of appearances of each dimension in the entire data set is presented as a percentage of the total number of

source-target pairs in the data set. As a result, note that the percentage values on the right column do not add up to 100% but exceeds it.

Table 7: Percentage occurrence of each dimension on the entire data

Dimensions	%-occurrence
Working Principle	44.6%
Structure	41.1%
Human Interaction	36.9%
Function	29.2%
Energy Flow	12.5%
Material Flow	10.1%
Purpose	1.2%
Behavior	0.6%

4.3 Observations and Inferences

The final data leads to the following observations:

1. All the eight dimensions of product similarity hypothesized in H1.2 of Section 1.4 are found to be used by designers, as shown in Figure 22, which supports that hypothesis.
2. Of the eight dimensions, purpose and behavior contribute to only 1% of analogies (see Figure 22). It is therefore believed that either these two dimensions do not play a significant role in analogy or the experiment failed to detect their roles. The first six dimensions in Figure 22 account for 99% of all analogies.
3. Of the eight dimensions, the top four, namely, working principle, structure, human interaction, and function are significantly dominant over the other dimensions, as previously pointed out in Figure 22. They account for 86% of the total number of similarities that lead to selecting a source product as a potential analogy reference for the target. It appears that as long as an analogy is possible to build using the first four dimensions, designers did not use material or energy flows to build their analogies.
4. Contrary to previous belief, function is not the most dominant or the only dominant dimension driving analogy in product design. Working principle proved

to be the most dominant dimension of similarity in this regard, while structure and human interaction were both more prevalent than function.

5. However, during the analysis and reconciliation of data, a strong connection between working principle and function was noted. It is out of the scope of this study to test how clearly designers discern between these two dimensions at a cognitive level. Assuming that the participants' distinction between these two dimensions is unreliable, the union of function and working principle into a single dimension would yield an even more dominant dimension of similarity.

In the following and last chapter, the conclusions drawn from this research are summarized and the future research directions are identified.

4.4 Limitations

The design of the main study relies on reconciliation between the coders, which is inherently subjective. While the approach of collecting the responses in plain-English rather than check boxes eliminates the dependency on the participants' interpretation of the dimension definitions, it increases the dependency on the coders. Some of the data was discarded prior to coding due to misunderstood instructions and ambiguous responses, while a small fraction was discarded during coding, due to the impossibility to categorize them under the dimensions. While the remaining data (61 sheets, 2,440 cells) was still a large set to support confident conclusions, the large rate of rejection shows a weakness in the objectivity of the study.

Another limitation is that the target product was presented as a picture, which does not correctly mimic the context of new product ideation because the form or picture of the solution is not supposed to be available during ideation. This limitation should be addressed in future studies.

Lastly, the participant pool had limited training in design methodology and had a weak representation of females due to the lopsided gender distribution in the engineering class used as participants, which may have skewed data toward the preference of males.

Chapter 5: Conclusions and Future Work

The research captured in this thesis presents two human-subject studies that investigate the dimensions of product similarity that designers use to detect a potential source product as an analogical reference to another product being designed. The results indicate designers use at least six different dimensions to draw analogy between target and source products, and that working principle, structure, and human interaction are more dominant in driving analogy than the other dimensions. This section summarizes the conclusions of the research and identifies some future research directions.

5.1 Answers to the Research Question and Contributions

The data from the study provide answers to the research questions, as follows:

5.1.1 Answer to RQ1

Hypothesis H1.2 is partially supported by the data. The data shows that designers certainly use more than one dimension of similarity for detecting source products as analogical references when designing a target product. There is clear evidence that at least six dimensions are used in this regard, which refer to the six larger slices in the pie chart of **Figure 22, and they include working principle, structure, human interaction, function, energy flows, and material flows.** There is insufficient evidence to claim that the dimensions of purpose and behavior also play roles in analogy (0.7% and 0.3% respectively). Since H1.2 hypothesized that all eight dimensions play a role, it is considered to be only partially supported.

5.1.2 Answer to RQ2

Hypothesis H2.2, which posited that function is the only dominant dimension of analogy, is also partially supported by the data. When considered alone, function did appear in the top four dimensions that contribute to analogy. However, it is not the most dominant or only dominant dimension. When lumped together with working principle, the combination of function and working principle forms the largest contributor to analogical reasoning. This H2.2 is only partially supported.

However, the research reported above leads to new learning about the nature of analogy in design. The dimensions of working principle, structure, and human interaction came out to be stronger contributors to analogy than function-based analogy. Contrary to previous beliefs regarding the dominance of function in analogy, this study establishes working principle, structure, and human interaction as strong drivers of analogy.

5.2 Future Work

The research project described in this thesis has opened up new directions of future research, some of which are being pursued currently. Two prominent ones are discussed below.

1. Like many other human-subject studies, it needs to be examined if the dimensions of similarity used to identify source products vary with the demographic of the population. Variations with gender, age, class standing within the engineering program, and the difference between novice and expert engineers are of particular interest. These trends should be examined in future research projects.
2. Based on the newfound realization that design-by-analogy is driven by more than just function-based similarity, one can imagine a computer tool that will recommend source products of analogy to the designer based on the six similarity dimensions discovered here from a database of solutions. With this tool, the designer will search for ideas for a target product, and the tool will offer other products that could serve as analogical references, much in a similar way that e-commerce websites suggest alternate products to buy. Such as tool is currently being designed by the author and his colleagues. This tool will be used in future studies to examine if and how the quality of design ideation is impacted by offering to the designer source products of analogy driven by the similarity dimensions other than function.

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Appendix A: Pilot Study Instruments

A.1 Training Instrument

Example survey for participant training session

Your task is to design this product:

Coffee Maker

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Manual Cheese grater	Mini mill	Water Dispenser	Dough mixer	Electric kettle
				
☐	☐	☐	☐	☐

Why did you choose these products?

☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions
☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):

A.2 Room Heater Instrument

Name: _____ 1

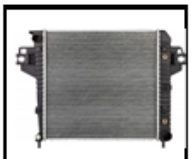
You are designing this product:

Room Heater

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Hair dryer machine ☐

Space heater ☐



Engine radiator ☐

Fan ☐

Automotive grill ☐

Why did you choose these products?

☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions
☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

A.3 Glue Gun Instrument

Name: _____ 2

You are designing this product:

Glue gun

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Blender

3D printer nozzle

Laser thermometer

Hair dryer

Popcorn hot-air popper

Why did you choose these products?

☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions
☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):

A.4 Hairdryer Instrument

Name: _____ 3

You are designing this product:

Hair dryer

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Hand drill ☐

Heat gun ☐

Space heater ☐

Glue gun ☐

Blender ☐

Why did you choose these products?

☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions
☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):

A.5 Drill Gun Instrument

Name: _____ 4

You are designing this product:

Drill gun

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Heat gun ☐

Power screwdriver ☐

Drill press ☐

Robotic vacuum ☐

Jig saw ☐

Why did you choose these products?

☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions
☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):

A.6 Blender Instrument

Name: _____ 5

You are designing this product:

Blender

Which of these suggestions would you like the database to return when you search for design ideas for the product shown above?

Hand blender

☐

Ice-cream dispenser

☐

Water filter

☐

Mini mill

☐

Electric juicer

☐

Why did you choose these products?

☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions	☐ Similar functions
☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form	☐ Similar form
☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions	☐ Similar motions
☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows	☐ Similar energy flows
☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows	☐ Similar material flows
☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):	☐ Others (specify):

Appendix B: Pilot Study Data

B.1 Room Heater Selections

Code	Product	Selections	Additional observations
1,1	Engine radiator	20	
1,0	Space heater	28	Signal actuator (on/off)
0,1	Automotive grill	4	
0.5,0.5	Fan	14	
0,0	Hair dryer machine	17	

B.2 Room Heater Selection by Dimensions

Code	Product	Function	Form	Motion	Energy	Material	Others
1,1	Engine radiator	12	18	16	14	7	0
1,0	Space heater	28	14	7	25	12	1
0,1	Automotive grill	2	3	2	2	0	0
0.5,0.5	Fan	10	1	3	5	4	0
0,0	Hair dryer machine	13	2	2	14	8	0

B.3 Glue Gun Selection

Code	Product	Selections	Additional observations
1,1	Hair dryer	21	
1,0	3D Printer nozzle	22	
0,1	Laser thermometer	14	Ergonomics, human-interface (*2)

0.5,0.5	Popcorn hot-air popper	4	
0,0	Blender	0	

B.4 Glue Gun Selection by Dimensions

Code	Product	Function	Form	Motion	Energy	Material	Others
1,1	Hair dryer	6	15	4	15	0	0
1,0	3D Printer nozzle	15	10	5	12	18	0
0,1	Laser thermometer	3	9	4	5	2	3
0.5,0.5	Popcorn hot-air popper	1	0	0	3	1	0
0,0	Blender	0	0	0	0	0	0

B.5 Hairdryer Selections

Code	Product	Selections	Additional observations
1,1	Heat gun	30	
1,0	Space heater	27	Ergonomics
0,1	Hand drill	5	Ergonomics/human interface
0.5,0.5	Glue gun	18	
0,0	Blender	1	

B.6 Hairdryer Selection by Dimensions

Code	Product	Function	Form	Motion	Energy	Material	Others
1,1	Heat gun	23	27	16	26	18	0
1,0	Space heater	22	5	3	24	18	1
0,1	Hand drill	1	3	0	3	0	1

0.5,0.5	Glue gun	5	12	2	13	0	0
0,0	Blender	0	0	1	1	0	0

B.7 Drill Gun Selections

Code	Product	Selections	Additional observations
1,1	Power screwdriver	30	
1,0	Drill press	29	limited environment of operation
0,1	Heat gun	7	
0.5,0.5	Jig saw	14	
0,0	Robotic vacuum	4	

B.8 Drill Gun Selection by Dimensions

Code	Product	Function	Form	Motion	Energy	Material	Others
1,1	Power screwdriver	26	29	27	23	13	0
1,0	Drill press	29	1	23	18	8	1
0,1	Heat gun	1	7	2	2	1	0
0.5,0.5	Jig saw	3	4	6	11	6	0
0,0	Robotic vacuum	1	0		2	1	0

B.9 Blender Selections

Code	Product	Selections	Additional observations
1,1	Electric juicer	24	Limited environment of operation
1,0	Hand blender	27	Cost (participants assumes this is cheaper)
0,1	Water filter	9	Suitable product to supplement the blender

0.5,0.5	Mini mill	22	
0,0	Ice-cream dispenser	4	

B.10 Blender Selections by Dimensions

Code	Product	Function	Form	Motion	Energy	Material	Others
1,1	Electric juicer	22	8	14	14	10	1
1,0	Hand blender	27	4	23	15	16	1
0,1	Water filter	2	3	3	3	2	1
0.5,0.5	Mini mill	19	5	17	13	5	0
0,0	Ice-cream dispenser	2	0	2	3	0	0

Appendix C: Main Study Instruments

C.1 Training Instrument

Example survey for participant training session

You are designing this product (Target product):

Excavator

From the five given products below:

1) In the red box,rate your level of familiarity with the given products (0-none, 1-somewhat, 2-fairly familiar)
2) Choose the product(s) that you would find useful in drawing inspiration for desgining the target product; do so by checking the blue box underneath the corresponding product

				
Shovel	Dump truck	Hair dryer	Crane	Bucket

Explain what you found useful in the product(s) you selected

Please check the box to indicate your interest in a further interview based study for this survey

C.2 Electric Kettle Instrument

Name: _____

P#

You are designing this product (Target product):

Electric kettle

From the five given products below:
1) In the red boxes, rate your level of familiarity with the given products. (**1 = very unfamiliar, 5 = very familiar**)
2) Choose the product(s) that you would find useful in drawing inspiration for desgining the target product; do so by checking the blue box underneath the corresponding product.

☐ ☐ ☐ ☐ ☐

3D printer nozzle

Glue gun

Drill press

Electric juicer

Robotic vacuum

☐ ☐ ☐ ☐ ☐

Explain what you found useful in the product(s) you selected.

☐ Please check the box to indicate your interest in a further interview based study for this survey

(1)

C.3 Glue Gun Instrument

Name: _____

You are designing this product (Target product):

P#

Glue gun

From the five given products below:
1) In the red boxes, rate your level of familiarity with the given products. (**1 = very unfamiliar, 5 = very familiar**)
2) Choose the product(s) that you would find useful in drawing inspiration for desgining the target product; do so by checking the blue box underneath the corresponding product.

Fan

3D printer nozzle

Hair dryer

Hand blender

Electric kettle

Explain what you found useful in the product(s) you selected.

Please check the box to indicate your interest in a further interview based study for this survey

(2)

C.4 Hairdryer Instrument

Name: _____

P#

You are designing this product (Target product):

Hair dryer

From the five given products below:

1) In the red boxes, rate your level of familiarity with the given products. (**1 = very unfamiliar, 5 = very familiar**)

2) Choose the product(s) that you would find useful in drawing inspiration for desgining the target product; do so by checking the blue box underneath the corresponding product.

Space heater

3D printer nozzle

Robotic vacuum

Glue gun

Drill gun

Explain what you found useful in the product(s) you selected.

Please check the box to indicate your interest in a further interview based study for this survey

(3)

C.5 Blender Instrument

Name: _____

You are designing this product (Target product): P#

Blender

From the five given products below:
1) In the red boxes, rate your level of familiarity with the given products. (**1 = very unfamiliar, 5 = very familiar**)
2) Choose the product(s) that you would find useful in drawing inspiration for desgining the target product; do so by checking the blue box underneath the corresponding product.

☐ ☐ ☐ ☐ ☐

3D printer nozzle ☐

Hand blender ☐

Space heater ☐

Fan ☐

Power screwdriver ☐

Explain what you found useful in the product(s) you selected.

_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____

☐ Please check the box to indicate your interest in a further interview based study for this survey

(5)

Appendix D: Main Study Data

**Independently rated data by 2 raters and the data consolidation for each participant

D.1 Participant P1 Data as Rated by Rater 1

Participant P1									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	0	1
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	0	0	0	0	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	1	0	0	0
Blender	Power screwdriver	0	0	0	0	0	0	0	0

D.2 Participant P1 Data as Rated by Rater 2

Participant P1									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	0	1

Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	0	0	0	0	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	1	0	0	0
Blender	Power screwdriver	0	0	0	0	0	0	0	0

D.3 Rater 1 and Rater 2 Data Consolidation for Participant P1

Participant P1									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E

Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Fan	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.4 Participant P2 Data as Dated by Rater 1

Participant P2									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	1	0	0	0	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	0	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	0	0	0	0	1	0	0
Blender	Power screwdriver	0	0	0	0	0	0	0	0

D.5 Participant P2 Data as Rated by Rater 2

Participant P2									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	1	0	0	0	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	0	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	0	0	0	0	1	0	0
Blender	Power screwdriver	0	1	0	0	0	0	0	0

D.6 Rater 1 and Rater 2 Data Consolidation for Participant

Participant P2									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	Disagree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Electric kettle	Electric juicer	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	Disagree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.7 Participant P3 Data as Rated by Rater 1

Participant P3									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	1	0	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	1	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	0	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0

D.8 Participant P3 Data as Rated by Rater 2

Participant P3

Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	1	0	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	1	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	0	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0

D.9 Rater 1 and Rater 2 Data Consolidation for Participant P3

Participant P3									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.10 Participant P4 Data as Rated by Rater 1

Participant P4									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	1	0

Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair Dryer	Space heater	0	1	0	0	0	0	0	0
Hair Dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair Dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair Dryer	Glue gun	0	1	0	0	1	0	0	0
Hair Dryer	Drill gun	0	0	0	0	0	0	1	0

D.11 Participant P4 Data as Rated by Rater 2

Participant P4									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair Dryer	Space heater	0	1	0	0	0	0	0	0
Hair Dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair Dryer	Robotic vacuum	0	0	0	0	0	0	0	0

Hair Dryer	Glue gun	0	1	0	0	1	0	0	0
Hair Dryer	Drill gun	0	0	0	0	0	0	1	0

D.12 Rater 1 & Rater 2 Data Consolidation for Participant P4

Participant P4									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair Dryer	Space heater	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair Dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair Dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair Dryer	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Hair Dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.13 Participant P5 Data as Rated by Rater 1

Participant P5									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	0	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	1	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	0	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	0	0	0	1	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	1	0

D.14 Participant P5 Data as Rated by Rater 2

Participant P5									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	0	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	1	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	0	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	0	0	0	1	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	1	0

D.15 Rater 1 & Rater 2 Data Consolidation for Participant P5

Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Blender	Fan	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.16 Participant P6 Data as Rated by Rater 1

Participant P6								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	0

D.17 Participant P6 Data as Rated by Rater 2

Participant P6								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	0

D.18 Rater 1 & Rater 2 data consolidation for Participant P6

Participant P6

Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

D.19 Participant P8 Data as Rated by Rater 1

Participant P8									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	1	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	1	0

D.20 Participant P8 Data as Rated by Rater 2

Participant P8									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	1	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0

Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	1	0

D.21 Rater 1 and Rater 2 Data Consolidation for Participant P8

Participant P8									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.22 Participant P9 Data as Rated by Rater 1

Participant P9									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	0	0	0	1	1	0	0
Glue gun	Hair dryer	0	1	0	0	0	0	1	1
Glue gun	Blender	0	0	0	0	0	0	0	0

Glue gun	Electric kettle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	1

D.23 Participant P9 Data as Rated by Rater 2

Participant P9									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	0	0	0	1	1	0	0
Glue gun	Hair dryer	0	1	0	0	0	0	1	1
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	1

D.24 Rater 1 and Rater 2 Data Consolidation for Participant P9

Participant P9									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	1-Agree

D.25 Participant P10 Data as Rated by Rater 1

Participant P10								
Target-to-Source	F	WP	B	P	S	M	HI	E

Electric kettle	3D printer nozzle	0	0	0	0	1	0	0	0
Electric kettle	Glue gun	1	1	0	0	1	1	1	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	1	0	0	1	1	0	0
Electric kettle	Robotic vacuum	0	0	0	0	1	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	1	0	0	0
Glue gun	Hair dryer	0	0	0	0	1	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	1	0	0	0

D.26 Participant P10 Data as Rated by Rater 2

Participant P10									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	1	0	0	0
Electric kettle	Glue gun	1	1	0	0	1	1	1	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	1	0	0	1	1	0	0
Electric kettle	Robotic vacuum	0	0	0	0	1	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0

Glue gun	3D printer nozzle	0	1	0	0	1	0	0	0
Glue gun	Hair dryer	0	0	0	0	1	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	1	0	0	0

D.27 Rater 1 and Rater 2 Data Consolidation for Participant P10

Participant P10									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	1-Agree	1-Agree	0-Agree	0-Agree	1-Agree	1-Agree	1-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	1-Agree	1-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Glue gun	Electric kettle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree

D.28 Participant P11 Data as Rated by Rater 1

Participant P11								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	1	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	1	1	0	0	0	0	0	0
Hair dryer	Drill gun	1	1	0	0	0	0	1	1
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	1	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.29 Participant P11 Data as Rated by Rater 2

Participant P11								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	1	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0

Hair dryer	Glue gun	1	1	0	0	0	0	0	0
Hair dryer	Drill gun	1	1	0	0	0	0	1	1
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	1	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.30 Rater 1 and Rater 2 Data Consolidation for Participant P11

Participant P11									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.31 Participant P1 Data as Rated by Rater 13

Participant P13									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	1	0	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	0	0	0	0	1	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	0	1	0	1	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	1	0	0	0	0	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	0	1

D.32 Participant P1 Data as Rated by Rater 13

Participant P13

Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	1	0	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	0	0	0	0	1	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	0	1	0	1	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	1	0	0	0	0	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	0	1

D.33 Rater 1 and Rater 2 Data Consolidation for Participant P13

Participant P13									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree

Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	1-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Fan	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree

D.34 Participant P14 Data as Rated by Rater 1

Participant P14								
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	1	0	0	0	0	0	0
Glue gun	Hair dryer	1	0	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	1	0	0	0	0	0	0

Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	1	1

D.35 Participant P14 Data as Rated by Rater 1

Participant P14									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	1	0	0	0	0	0	0
Glue gun	Hair dryer	1	0	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	1	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	1	1

D.36 Rater 1 and Rater 2 Data Consolidation for Participant P14

Participant P14									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Glue gun	3D printer nozzle	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree

D.37 Participant P16 Data as Rated by Rater 1

Participant P16									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	1	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	1	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	1

D.38 Participant P16 Data as Rated by Rater 2

Participant P16								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	1	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	1	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	1

D.39 Rater 1 & Rater 2 Data Consolidation for Participant P16

Participant P16									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	1-Agree

D.40 Participant P17 Data as Rated by Rater 1

Participant P17								
Target-to-Source	F	WP	B	P	S	M	HI	E

Electric kettle	3D printer nozzle	0	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	1	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	0	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	0	0	1	0
Blender	Space heater	0	0	0	0	0	0	1	0
Blender	Fan	0	0	0	0	0	0	0	0
Blender	Power screwdriver	0	0	0	0	0	0	1	0

D.41 Participant P17 Data as Rated by Rater 2

Participant P17									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	1	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	0	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	0	0	1	0

Blender	Space heater	0	0	0	0	0	0	1	0
Blender	Fan	0	0	0	0	0	0	0	0
Blender	Power screwdriver	0	0	0	0	0	0	1	0

D.42 Rater 1 & Rater 2 Data Consolidation for Participant P1

Participant P17									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Blender	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Blender	Power screwdriver	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.43 Participant P18 Data as Rated by Rater 1

Participant P18								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	0	0	0	1	0	1	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	1	0	0	0	1	0	1	0
Hair dryer	Drill gun	0	0	0	0	1	0	0	0

D.44 Participant P18 Data as Rated by Rater 2

Participant P18								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	0	0	0	1	0	1	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	1	0	0	0	1	0	1	0
Hair dryer	Drill gun	0	0	0	0	1	0	0	0

D.45 Rater 1 and Rater 2 Data Consolidation for Participant P18

Participant P18								
Target-to-Source	F	WP	B	P	S	M	HI	E

Hair dryer	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree

D.46 Participant P19 Data as Rated by Rater 1

Participant P19								
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	1	0	0	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	0	0	0	1	0	0	0
Drill gun	Hair dryer	0	0	0	0	1	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	1	0	0	1
Blender	Space heater	0	1	0	0	0	0	0	1
Blender	Fan	0	1	0	0	0	0	0	1
Blender	Power screwdriver	0	0	0	0	0	0	1	0

D.47 Participant P19 Data as Rated by Rater 2

Participant P19									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	1	0	0	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	0	0	0	1	0	0	0
Drill gun	Hair dryer	0	0	0	0	1	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	0	1	0	0	1	0	0	1
Blender	Space heater	0	1	0	0	0	0	0	1
Blender	Fan	0	1	0	0	0	0	0	1
Blender	Power screwdriver	0	0	0	0	0	0	1	0

D.48 Rater 1 and Rater 2 Data Consolidation for Participant P19

Participant P19									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree

Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree
Blender	Space heater	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree
Blender	Fan	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree
Blender	Power screwdriver	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.49 Participant P20 Data as Rated by Rater 1

Participant P20									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	1	0
Drill gun	Drill press	0	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.50 Participant P20 Data as Rated by Rater 2

Participant P20

Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	1	0
Drill gun	Drill press	1	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.51 Rater 1 and Rater 2 Data Consolidation for Participant P20

Participant P20									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Drill press	Disagree	Disagree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.52 Participant P21 Data as Rated by Rater 1

Participant P21									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0

Electric kettle	Glue gun	0	0	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	1	0	0	0
Electric kettle	Electric juicer	0	1	0	0	1	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	0	0	0	1	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	0	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	1	0

D.53 Participant P21 Data as Rated by Rater 2

Participant P21									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	0	0	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	1	0	0	0
Electric kettle	Electric juicer	0	1	0	0	1	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	0	0	0	1	0	0	0
Blender	Space heater	0	0	0	0	0	0	0	0

Blender	Fan	0	1	0	0	0	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	1	0

D.54 Rater 1 and Rater 2 Data Consolidation for Participant P21

Participant P21								
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Fan	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.55 Participant P23 Data as Rated by Rater 1

Participant P23								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	0	0

D.56 Participant P23 Data as Rated by Rater 2

Participant P23								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	0	0

D.57 Rater 1 and Rater 2 Data Consolidation for Participant P23

Participant P23									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree

D.58 Participant P24 Data as Rated by Rater 1

Participant P24									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	0	0	0	1	1	0	0
Glue gun	Hair dryer	1	0	0	0	0	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	0	0	0	1	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair Dryer	Space heater	1	1	0	0	1	1	0	0
Hair Dryer	3D printer nozzle	0	0	0	0	1	0	0	0
Hair Dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair Dryer	Glue gun	0	0	0	0	1	0	1	0
Hair Dryer	Drill gun	0	0	0	0	0	0	1	0

D.59 Participant P24 Data as Rated by Rater 2

Participant P24

Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	0	0	0	1	1	0	0
Glue gun	Hair dryer	1	0	0	0	0	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	0	0	0	1	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair Dryer	Fan	1	1	0	0	1	1	0	0
Hair Dryer	3D printer nozzle	0	0	0	0	1	0	0	0
Hair Dryer	Hair dryer	0	0	0	0	0	0	0	0
Hair Dryer	Blender	0	0	0	0	1	0	1	0
Hair Dryer	Electric kettle	0	0	0	0	0	0	1	0

D.60 Rater 1 and Rater 2 Data Consolidation for Participant P24

Participant P24									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Glue gun	Electric kettle	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair Dryer	Fan	1-Agree	1-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree
Hair Dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Hair Dryer	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair Dryer	Blender	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Hair Dryer	Electric kettle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

D.61 Participant P25 Data as Rated by Rater 1

Participant P25									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	1	0	0	1	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	1	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	1	0	0	0	0	0	0	0

Drill gun	Hair dryer	0	0	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.62 Participant P25 Data as Rated by Rater 2

Participant P25									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	1	0	0	1	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	1	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	1	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.63 Rater 1 and Rater 2 Data consolidation for Participant P25

Participant P25									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	1-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree

Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	Disagree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.64 Participant P26 Data as Rated by Rater 1

Participant P26									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	1	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	1	0

Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	0	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	1	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.65 Participant P26 Data as Rated by Rater 2

Participant P26									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	0	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	1	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	0	0	1	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	0	0	0	0
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	1	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.66 Rater 1 and Rater 2 Data Consolidation for Participant P26

Participant P26									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	Disagree	Disagree	0-Agree	0-Agree	0-Agree	Disagree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.67 Participant P28 Data as Rated by Rater 1

Participant P28								
Target-to-Source	F	WP	B	P	S	M	HI	E

Drill gun	Jig saw	0	1	0	0	0	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	1	0	0	0	1	0	0	0
Drill gun	Hair dryer	0	1	0	0	1	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	1	0	0	0	0	1	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	1	0	1	0
Blender	Power screwdriver	0	0	0	0	0	0	0	0

D.68 Participant P28 Data as Rated by Rater 2

Participant P28									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	0	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	1	0	0	0	1	0	0	0
Drill gun	Hair dryer	0	1	0	0	1	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	1	0	0	0	0	1	0

Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	1	0	1	0
Blender	Power screwdriver	0	0	0	0	0	0	0	0

D.69 Rater 1 and Rater 2 Data Consolidation for Participant P28

Participant P28									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Fan	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

Blender	Power screwdriver	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.70 Participant P30 Data as Rated by Rater 1

Participant P30								
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	1	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.71 Participant P30 Data as Rated by Rater 2

Participant P30								
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	0	1	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	0	0
Drill gun	Drill press	0	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.72 Rater 1 and Rater 2 Data Consolidation for Participant P30

Participant P30								
Target-to-Source	F	WP	B	P	S	M	HI	E

Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	1-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.73 Participant P32 Data as Rated by Rater 1

Participant P32									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	1	1	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	0	0	0	1	1	0	1
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	0	0	0	0	0	0	0
Glue gun	Hair dryer	1	1	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	1	0	1	0

D.74 Participant P32 Data as Rated by Rater 2

Participant P32									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	1	1	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	0	0	0	1	1	0	1
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	0	0	0	0	0	0	0
Glue gun	Hair dryer	1	1	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	1	0	1	0

D.75 Rater 1 and Rater 2 Data Consolidation for Participant P32

Participant P32									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Electric kettle	Electric juicer	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	1-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

D.76 Participant P33 Data as Rated by Rater 1

Participant P33									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	1	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	1	0	1	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	1	0	0	0

Glue gun	Hair dryer	0	0	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	1	0	0	0	0	0	0

D.77 Participant P33 Data as Rated by Rater 2

Participant P33									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	1	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	1	0	1	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	1	0	0	0
Glue gun	Hair dryer	0	0	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	1	0	0	0	0	0	0

D.78 Rater 1 and Rater 2 Data Consolidation for Participant P33

Participant P33								
Target-to-Source	F	WP	B	P	S	M	HI	E

Electric kettle	3D printer nozzle	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.79 Participant P35 Data as Rated by Rater 1

Participant P35									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	1	0	0	0
Hair dryer	3D printer nozzle	0	1	0	0	1	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0

Hair dryer	Glue gun	0	1	0	0	1	0	1	0
Hair dryer	Drill gun	0	1	0	0	0	0	1	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	1	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	1	0
Drill gun	Drill press	1	1	0	0	0	0	1	1
Drill gun	Hair dryer	0	1	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.80 Participant P35 Data as Rated by Rater 2

Participant P35									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	1	0	0	0
Hair dryer	3D printer nozzle	0	1	0	0	1	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	1	0	0	1	0	1	0
Hair dryer	Drill gun	0	1	0	0	0	0	1	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	1	0	1	1
Drill gun	Glue gun	0	0	0	0	0	0	1	0
Drill gun	Drill press	1	1	0	0	0	0	1	1
Drill gun	Hair dryer	0	1	0	0	0	0	1	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.81 Rater 1 & Rater 2 data consolidation for Participant P35

Participant P35									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	1-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Drill press	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Drill gun	Hair dryer	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.82 Participant P36 Data as Rated by Rater 1

Participant P36								
Target-to-Source	F	WP	B	P	S	M	HI	E

Hair dryer	Space heater	0	1	0	0	0	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	1	0	0	0	1	0	0
Hair dryer	Glue gun	1	1	0	0	0	0	0	0
Hair dryer	Drill gun	0	1	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	0	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	1	0
Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	1	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.83 Participant P36 Data as Rated by Rater 2

Participant P36									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	0	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	1	0	0	0	1	0	0
Hair dryer	Glue gun	1	1	0	0	0	0	0	0
Hair dryer	Drill gun	0	1	0	0	1	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	1	0	0	0	0	1	0
Drill gun	Glue gun	0	0	0	0	0	0	1	0

Drill gun	Drill press	0	1	0	0	0	0	0	0
Drill gun	Hair dryer	0	1	0	0	0	0	0	0
Drill gun	3D printer nozzle	0	0	0	0	0	0	0	0

D.84 Rater 1 and Rater 2 Data Consolidation for Participant P36

Participant P36								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	1-Agree	0-Agree	0-Agree	Disagree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Drill press	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Hair dryer	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.85 Participant P38 Data as Rated by Rater 1

Participant P38									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	1	0	0	0
Glue gun	Hair dryer	0	0	0	0	1	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	1	0	0	1	0	1	0

D.86 Participant P38 Data as Rated by Rater 2

Participant P38									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	1	0	0	0
Glue gun	Hair dryer	0	0	0	0	1	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	1	0	0	1	0	1	0

D.87 Rater 1 and Rater 2 Data Consolidation for Participant P38

Participant P38								
Target-to-Source	F	WP	B	P	S	M	HI	E

Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	1-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

D.88 Participant P39 Data as Rated by Rater 1

Participant P39								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	1	1	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	0

D.89 Participant P39 Data as Rated by Rater 2

Participant P39								
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1	0	0	0	0	1	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	1	1	0	0	0	0	0	0

Hair dryer	Glue gun	0	0	0	0	0	0	0	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	0

D.90 Rater 1 and Rater 2 Data Consolidation for Participant

Participant P39									
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

D.91 Participant P41 Data as Rated by Rater 1

Participant P41									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	0	0	0	0	0	0	0
Glue gun	Hair dryer	0	1	0	0	1	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	1	0	0	0	0	0	0

D.92 Participant P41 Data as Rated by Rater 2

Participant P41									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	0	0	0	0	0	0	0
Glue gun	Hair dryer	0	1	0	0	1	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	1	0	0	0	0	0	0

D.93 Rater 1 and Rater 2 Data Consolidation for Participant P41

Participant P41									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.94 Participant P42 Data as Rated by Rater 1

Participant P42									
Target-to-Source		F	WP	B	P	S	M	HI	E

Drill gun	Jig saw	0	0	0	1	0	0	0	0
Drill gun	Glue gun	0	0	0	0	1	0	1	0
Drill gun	Drill press	1	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	1	0	1	1
Drill gun	3D printer nozzle	0	0	0	1	1	0	0	0

D.95 Participant P42 Data as Rated by Rater 2

Participant P42									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0	0	0	1	0	0	0	0
Drill gun	Glue gun	0	0	0	0	1	0	1	0
Drill gun	Drill press	1	0	0	0	0	0	0	0
Drill gun	Hair dryer	0	0	0	0	1	0	1	1
Drill gun	3D printer nozzle	0	0	0	1	1	0	0	0

D.96 Rater 1 and Rater 2 Data Consolidation for Participant P42

Participant P42									
Target-to-Source		F	WP	B	P	S	M	HI	E
Drill gun	Jig saw	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Drill gun	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Drill gun	Drill press	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

Drill gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	1-Agree
Drill gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree	0-Agree

D.97 Participant P43 Data as Rated by Rater 1

Participant P43									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	0	0	0	0	0	0	0	1
Electric kettle	Drill press	0	0	0	0	1	0	0	0
Electric kettle	Electric juicer	1	0	0	0	1	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	1	1
Glue gun	3D printer nozzle	1	0	0	0	0	0	0	0
Glue gun	Hair dryer	1	0	0	0	1	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	0	0	0	0	0	0	0

D.98 Participant P43 Data as Rated by Rater 2

Participant P43									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	0	0	0	0
Electric kettle	Glue gun	0	0	0	0	0	0	0	1

Electric kettle	Drill press	0	0	0	0	1	0	0	0
Electric kettle	Electric juicer	1	0	0	0	1	0	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	1	1
Glue gun	3D printer nozzle	1	0	0	0	0	0	0	0
Glue gun	Hair dryer	1	0	0	0	1	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	0	0	0	0	0	0	0

D.99 Rater 1 and Rater 2 Data Consolidation for Participant P43

Participant P43									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E

Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Glue gun	3D printer nozzle	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.100 Participant P44 Data as Rated by Rater 1

Participant P44									
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	1	0	0	1	0	0	0
Blender	Space heater	0	0	0	0	1	0	1	0
Blender	Fan	0	0	0	0	0	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	0	0

D.101 Participant P44 Data as Rated by Rater 2

Participant P44									
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	0	0	0	0
Blender	Hand blender	1	1	0	0	1	0	0	0
Blender	Space heater	0	0	0	0	1	0	1	0

Blender	Fan	0	0	0	0	0	0	0	0
Blender	Power screwdriver	0	1	0	0	0	0	0	0

D.102 Rater 1 and Rater 2 Data consolidation for Participant P44

Participant P44								
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	1-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Blender	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.103 Participant P45 Data as Rated by Rater 1

Participant P45									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	1	1	0	0
Electric kettle	Glue gun	1	0	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	0	0	0	1	1	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	1	0

Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	1	0	0	0
Blender	Hand blender	0	0	0	0	1	0	1	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	1	0	0	0
Blender	Power screwdriver	0	1	0	0	0	1	0	0

D.104 Participant P45 Data as Rated by Rater 2

Participant P45									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	0	0	0	1	1	0	0
Electric kettle	Glue gun	1	0	0	0	0	0	0	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	1	0	0	0	1	1	0	0
Electric kettle	Robotic vacuum	0	0	0	0	0	0	1	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0	0	0	0	1	0	0	0
Blender	Hand blender	0	0	0	0	1	0	1	0
Blender	Space heater	0	0	0	0	0	0	0	0
Blender	Fan	0	1	0	0	1	0	0	0
Blender	Power screwdriver	0	1	0	0	0	1	0	0

D.105 Rater 1 and Rater 2 Data Consolidation for Participant P45

Participant P45									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree	0-Agree	0-Agree
Electric kettle	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Blender	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Hand blender	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree
Blender	Space heater	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Blender	Fan	0-Agree	1-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Blender	Power screwdriver	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree

D.106 Participant P47 Data as Rated by Rater 1

Participant P47								
Target-to-Source	F	WP	B	P	S	M	HI	E

Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	0	0	0	1	0	0	0
Glue gun	Hair dryer	1	0	0	0	0	0	1	1
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	1	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0
Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	1	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	0

D.107 Participant P47 Data as Rated by Rater 2

Participant P47									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	0	0	0	0	1	0	0	0
Glue gun	Hair dryer	1	0	0	0	0	0	1	1
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	1	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0	1	0	0	0	0	0	0
Hair dryer	3D printer nozzle	0	0	0	0	0	0	0	0

Hair dryer	Robotic vacuum	0	0	0	0	0	0	0	0
Hair dryer	Glue gun	0	0	0	0	0	0	1	0
Hair dryer	Drill gun	0	0	0	0	1	0	1	0

D.108 Rater 1 and Rater 2 Data Consolidation for Participant P47

Participant P47									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	1-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Hair dryer	Space heater	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	3D printer nozzle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Robotic vacuum	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Hair dryer	Glue gun	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree

Hair dryer	Drill gun	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	1-Agree	0-Agree

D.109 Participant P4 Data as Rated by Rater 1

Participant P48									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	1	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0
Electric kettle	Electric juicer	0	0	0	0	0	0	0	1
Electric kettle	Robotic vacuum	0	1	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	1	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	0	1	0	0
Glue gun	Hair dryer	0	0	0	0	0	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	0	0	0	0

D.110 Participant P4 Data as Rated by Rater 2

Participant P48									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0	1	0	0	0	0	0	0
Electric kettle	Glue gun	0	1	0	0	0	0	1	0
Electric kettle	Drill press	0	0	0	0	0	0	0	0

Electric kettle	Electric juicer	0	0	0	0	0	0	0	1
Electric kettle	Robotic vacuum	0	1	0	0	0	0	0	0
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	1	0	0	0
Glue gun	3D printer nozzle	0	1	0	0	0	1	0	0
Glue gun	Hair dryer	0	0	0	0	0	0	1	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	0	0	0	0

D.111 Rater 1 and Rater 2 Data Consolidation for Participant P48

Participant P48									
Target-to-Source		F	WP	B	P	S	M	HI	E
Electric kettle	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Glue gun	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Electric kettle	Drill press	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Electric kettle	Electric juicer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree
Electric kettle	Robotic vacuum	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree

Glue gun	3D printer nozzle	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree

D.112 Participant P4 Data as Rated by Rater 1

Participant P50									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	0	0	0	1	0	0	0
Glue gun	Hair dryer	0	1	0	0	0	0	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	0	0	0	0	0	0	0	0

D.113 Participant P4 Data as Rated by Rater 2

Participant P50									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0	0	0	0	0	0	0	0
Glue gun	3D printer nozzle	1	0	0	0	1	0	0	0
Glue gun	Hair dryer	0	1	0	0	0	1	0	0
Glue gun	Blender	0	0	0	0	0	0	0	0
Glue gun	Electric kettle	1	1	0	0	0	1	1	0

D.114 Rater 1 and Rater 2 Data Consolidation for Participant P50

Participant P50									
Target-to-Source		F	WP	B	P	S	M	HI	E
Glue gun	Fan	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	3D printer nozzle	1-Agree	0-Agree	0-Agree	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Hair dryer	0-Agree	1-Agree	0-Agree	0-Agree	0-Agree	Disagree	0-Agree	0-Agree
Glue gun	Blender	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree	0-Agree
Glue gun	Electric kettle	Disagree	Disagree	0-Agree	0-Agree	0-Agree	Disagree	Disagree	0-Agree