FROM TRASH TO TREASURE:

HOW BROKEN PRODUCTS LEAD TO NEW IDEAS

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Abstract

Consumer products often break. When this happens, the consumer is confronted with a decision which will determine how the product is used from that point onward. In this dissertation, I examine the psychological processes at play when interacting with a product that is broken, as opposed to functional, and find that broken products (e.g., broken wagons) serve as excellent creative inputs for generating novel product uses. I provide a synopsis of key theories from the literature on creative problem-solving and argue that functional products facilitate functional fixedness, or fixation on salient or conventional product uses. I present findings from seven experiments examining the effects of interacting with broken products on novel use generation and disposal behavior. I use these findings to argue that functional fixedness is an artifact of a chunking process that occurs when interacting with objects during problem solving, and assert that contextual effects which disrupt this process attenuate functional fixedness and enable the generation of novel ideas. I find that broken products are less likely to be treated as coherent wholes (chunks) and more likely to be treated as disparate parts (decomposed chunks), which reduces functional fixedness and allows for the generation of uses which deviate from the norm. Furthermore, I find evidence that the chunking of functional products and the chunk decomposition of broken products impacts recycling behavior; broken products are recycled more readily as a result of being viewed in terms of their component parts, facilitating the sorting of product components into separate recycling bins. I conclude by discussing the theoretical and managerial implications of these findings and suggest that designing products with disassembly in mind may facilitate creative reuse and recycling behaviors, reducing the amount of waste caused by the rapid acquisition, consumption, and disposal of consumer products.

Lay Summary

Consumer products often break. Sometimes, consumers use this opportunity to come up with new and interesting ways to use products instead of throwing them in the garbage. In this dissertation, I conducted several experiments in order to find out what it is about broken products that seems to encourage creativity. I found that when products (e.g., wagons) are functioning normally, consumers tend to use them in unimaginative ways (e.g., giving rides to children). However, when a product breaks, this disrupts consumers' habitual thought processes, allowing them to see the product in a new light and come up with creative uses for it (e.g., using a wagon as a sandbox). Consumers feel free to take broken products apart, which aids the creative process and even makes it easier to recycle the products. I suggest that businesses should design products that are easy to take apart, which would encourage consumers to reuse them in creative ways and make recycling them more convenient.

Preface

This dissertation is original and unpublished work authored by Wade Wade under the guidance and supervision of JoAndrea Hoegg and Darren Dahl at the University of British Columbia. Additional guidance was provided by Ravi Mehta at the University of Illinois at Urbana-Champaign. Ethical approval for the research presented herein was obtained from the UBC Office of Research Services Behavioural Review Board (Human Ethics) under the certificates H18-03231 and H21-02255.

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Glossary

Appropriateness: Refers to ideas or creative products which are effective, practical, or contextually appropriate (Amabile, 1993).

Broken Products: Objects which have lost functionality through damage or deterioration over time.

Chunk: A collection of elements having strong associations with one another, but weak associations with other collections of elements (Gobet et al, 2001).

Chunk Decomposition: Refers to breaking chunks into parts (Knoblich et al, 1999).

Chunking: The creation of chunks (Gobet, Lloyd-Kelly, and Lane, 2016).

Constraints: Rules or limitations associated with the problem. Can be explicit attributes of the task environment or implicit attributes of the problem representation. Constraints bound the problem space (Knoblich et al, 1999; Stokes, 2007).

Creativity: Refers to the concurrence of ideas or creative products which are both novel and appropriate (Amabile, 1993).

Functions: Refers to manipulations which can be applied to an object to achieve a goal (Saugstad, 1958). Synonymous with uses.

Functional Fixedness: Fixation on salient or conventional object uses. Implies inhibition of novel or unusual object use generation (Duncker, 1945).

Fixation Effects: A class of psychological effects characterized by a counterproductive or undesirable effect of information active in memory (Smith, 1995; Finke et al, 1992).

Insight Problem: A problem which is solved by restructuring one's problem representation (Ohlsson, 1984).

Novelty: Refers to ideas or creative products which are new, original, unique, unusual, atypical, or unconventional from the perspective of expert judges (Amabile, 1982). Novelty is a function of variability or deviance from the norm (Stokes, 2007).

Parts: Refers to components of objects which have the characteristic of being dissimilar to other components as well as dissimilar to the object in its entirety (Winston et al, 1987).

Pre-inventive Structure: A partial or incomplete symbol structure which possesses potential for transformation into novel symbol structures (Finke et al, 1992).

Problem: A goal or task impeded by an obstacle (Burroughs and Mick, 2004).

Problem Representation: An interpretation, formulation, or construal of the problem at hand (Duncker, 1945; Newell and Simon, 1972; Knoblich et al, 1999). Problem representations determine the problem space.

Problem Space: The mental representation of the task environment; a navigable set of situation states within which problem solving occurs. Composed of an initial state, operators which can be applied to make transformations to the initial state, and a goal state (Newell and Simon, 1972; Ohlsson, 1984). The size of the problem space is not limited by working memory capacity.

Symbol Structure: Refers to patterns of information which refer to a reference object. These symbol structures serve as highly malleable building blocks of thought (Newell and Simon, 1972).

Task Environment: The external context in which problem solving takes place. Includes explicit task constraints (Newell and Simon, 1972).

Transfer: Application of information from one task to another task (Nokes, 2009).

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Dedication

This dissertation is dedicated to my wife, Chris Wade, who has supported me more than I will ever know.

Chapter 1: Introduction

Intense competition among manufacturers in the 1920's led to the development and proliferation of a marketing strategy known as planned obsolescence (Slade, 2009; Fairfield, 2017). Planned obsolescence refers to the development of products with artificially low lifespans in order to encourage frequent repeat sales (Kramer, 2012). This strategy is often paired with the development of an incrementally improved version of the current product offering on a periodic basis—a standard practice in, for example, the automotive and smartphone industries. The economic advantages of this marketing strategy for manufacturers are obvious, and it has been argued that planned obsolescence plays a critical role in driving innovation and economic growth (Fishman et al, 1993; Rivera and Lallmahomed, 2016). However, this strategy has also contributed to substantial growth in wasteful product disposal over the last century (Rivera and Lallmahomed, 2016). In the United States alone, over 290 million tons of garbage is accumulated each year (EPA, 2018).

At present, there is a conflict between firms that benefit from planned obsolescence and consumer advocacy groups that desire greater product longevity and unrestricted access to product reuse and repair. This consumer movement, known as the right to repair movement, has developed in response to decades of decisions made by manufacturers such as John Deere, GM, and Apple to artificially reduce product longevity and constrain the freedom of consumers to modify and repair their own products according to their own needs and by their own means (The Repair Association, 2022). On July 1st, 2021, American President Joe Biden signed an executive order protecting consumers' rights to repair and modify products that they have purchased (Cable News Network, 2021). The success of the right to repair movement underscores a consumer value—the freedom to use, repair, and modify purchased products without constraint.

Unsustainable waste production, planned obsolescence, product ownership rights, and other related phenomena are entangled into an immensely complex system. I have chosen to examine one portion of this system. Specifically, this dissertation is an exploration of the creative cognition that occurs in the mind of an individual consumer when confronted with a product that is not functional. More specifically, my primary research question is whether the functionality of a product—or lack thereof—affects the novelty of uses that the consumer is able to generate for that product. The ability to generate novel uses for broken products may play a causal role in regards to how the consumer chooses to use the product and is an antecedent to the decision to creatively reuse it as an alternative to disposal.

I have chosen to study the broken product context for two reasons. First, the moment that a product breaks initiates a consumer disposal decision. Within this moment, the consumer decides whether to reuse the product, dispose of it, or defer the disposal decision to some future moment. The decision that the consumer pursues can yield important consequences for the consumer, the producer, and the environment. Second, a broken product represents a rich stimulus for understanding the cognitive psychology of consumption. I explore this stimulus as a means of contributing theoretically to the literatures on problem-solving and creative cognition, with specific attention paid to the phenomena of chunking/chunk decomposition and functional fixedness.

My thesis is that consumers are more creative with products that are broken. I have structured this dissertation in order to develop this thesis on both theoretical and empirical grounds. The current chapter (Chapter 1) introduces the dissertation topic and outlines the structure of the document. In Chapter 2, I provide a synopsis of several theories on the psychology of problem-solving. The theories that I chose to feature here were selected based on their relevance as frameworks for understanding how consumers use objects, how perceptions of objects change in response to sudden contextual shifts, and how information is combined or separated during the pursuit of consumer goals. The theories covered include the Gestalt account of insight problem-solving (Duncker, 1945), the Geneplore model (Finke et al, 1992), representation change theory (Knoblich et al, 1999), information processing theory (Newell and Simon, 1972), and the paired constraint model of novelty (Stokes, 2007). I use these diverse (but complementary) theoretical perspectives to develop an understanding of the phenomenon of functional fixedness and construct hypotheses regarding its causes. Additionally, I review the literature on functional fixedness and a wide variety of topics associated with it. I discuss the unusual uses task (Guilford, 1967), which is a measure commonly used to study creativity in the consumer context (Finke et al, 1992). Finally, I develop hypotheses regarding potential downstream consequences of interacting creatively with broken products based on phenomena conceptually adjacent to novel use generation. In Chapter 3, I present a series of experiments which were conducted to establish and explain an effect of product functionality on novel product use generation. In Chapter 4, I present a series of experiments designed to demonstrate substantive downstream consequences of engaging creatively with broken products. In Chapter 5, I summarize my findings, discuss how they contribute to existing literature, address limitations and alternative explanations, and explore potential avenues for future research on this topic. Additional information can be found in the appendices. Appendix A contains the study materials used. Appendix B provides descriptive statistics and robustness checks for findings reported in Chapters 3 and 4. Appendix C contains pre-registrations for Studies 3-7.

Chapter 2: Literature Review

2.1 Functional Fixedness: Early Insights from Gestalt Psychology

A brief overview of the history of research on functional fixedness will be instrumental in framing our understanding of the phenomenon. Research on functional fixedness began with the seminal work of the Gestalt psychologist Karl Duncker (1945). During this period, research in psychology was dominated by the Behaviorist school of thought, which explicitly rejected the study of psychological phenomena which were not publicly observable, essentially excluding consciousness from the domain of psychology (Watson, 1913; Harzem, 2004). In contrast, the Gestalt psychologists operated under a heterodox paradigm in which conscious thought processes were of primary interest. In brief, the Gestalt school of thought emphasized the notion that the mind constructs whole patterns—gestalts—which are projected onto the environment. These gestalts are qualitatively different from the piecemeal information found in the environment. Famously, Kurt Koffka affirmed that "The whole is different from the sum of its parts" (as cited in Heider, 1977, p. 383). This is a statement on the structure of thought. Gestalt psychologists used experimentation with visual illusions to illustrate this point; if the structures in the mind were merely the sum of the parts which compose them, people would not report seeing whole structures when there were none. At present, much of their work on optical illusions is interpreted as illustrations of cases where an otherwise functional bottom-up visual system breaks down (Kanizsa, 1994). However, the Gestalt psychologists' research on visual illusions were conducted to provide support for a more radical claim. For the Gestaltists, structures in the mind are not merely determined by the arrangement of piecemeal information from the environment. This view would be better described as the whole being *equal* to or *greater than* the sum of its parts. Rather, the Gestaltists argued that Gestalts are qualitatively different from the information that they are composed of (Rock and Palmer, 1990; Wagemans et al, 2012). A priori, given an array of parts, we are unable to precisely calculate the whole that will be produced when they are arranged together. Much of the work of the Gestalt psychologists was thus concerned with how the mind generates these Gestalts. Because the mainstream psychologists of their day excluded elements of conscious thought, whole or otherwise, from their domain of study, this school of thought was uniquely positioned to serve as the springboard for the psychological study of problem solving and creativity. At present, their work continues to influence research on insight problem solving (Knoblich et al, 1999; Wagemans et al, 2012; Jäkel et al, 2016).

In an early treatise on problem-solving, Duncker (1945) used thought protocols to empirically examine the procedures that people use to solve problems. From these observations, he formed an early theory of what we now call insight problem solving (Scheerer, 1963; Smith and Blankenship, 1991; Sternberg and Davidson, 1995; Knoblich et al, 1999; Öllinger et al, 2008). According to Duncker, problem solvers first approach a problem by constructing a formulation of the problem. This formulation provides the basis for deriving a solution procedure. That is to say, the way the problem solver formulates the problem determines the solutions that they will generate. For insight problems, this approach tends to lead to an initial failure. That is because insight problems follow a pattern of exploration-impasse-insight-execution (Poincaré, 1908/1952). The initial problem formulation for these types of problems will lead to a solution procedure that culminates at an impasse. According to Duncker (1945), problem solvers use information from each failed attempt to revise their problem formulation. Eventually, they come to recognize the “functional value” of the problem’s solution, or the “by-means-of-which" a solution is effective (p. 4). For example, when attempting to rekindle a fire, one class of successful solutions will contain the functional value of increasing the fire's oxygen supply. Such solutions would be effective because they hold this functional value. Once a problem solver is able to identify the functional value associated with the problem at hand, they reformulate their problem representation, and this reformulation is often accompanied by a sudden "Aha!" experience as the pathway to a successful solution is realized. This experience exemplifies the formation of a Gestalt, which is marked by a sudden and illuminating "Gestalt switch" as an array of disparate parts is combined to form a unified, complete pattern in the mind. The insight problems studied by Duncker and many of those studied in the insight problem-solving literature to date feature the unusual use of an object as instrumental to reaching an insightful solution. Using objects in unusual ways is often unintuitive, and this phenomenon can be employed as an impasse for insight problems. The cognitive bias that is at work in these types of insight problems is called functional fixedness, which is defined as the tendency to fixate on a salient or conventional function of an object (Duncker, 1945; Adamson, 1952). Duncker described functional fixedness as a bias that prevents problem solvers from perceiving functions that are dissimilar to the functions which have been previously used. Here, I will review some of the classic insight problems studied in psychology to illustrate the phenomenon of functional fixedness.

2.1.1 The Candle Problem

In Duncker's famous candle problem, participants were provided with three candles, three boxes, some matches, some tacks, and several distractor objects. They were then asked to devise a way to attach the candle to the wall in such a way that the candle, while lit, does not cause wax to drip to the floor. The three boxes provided to participants were either empty or filled with experimental stimuli (candles, tacks, and matches). The correct solution to this problem is to pin the boxes to the wall, using them as platforms for the lit candles. Duncker observed that participants who were provided with boxes containing experimental materials tended to fixate on this salient function of boxes (i.e., using the boxes as containers). This fixation served as an obstacle to finding the solution, which required using the boxes as platforms which could be attached to the wall using thumb tacks to serve as a makeshift candle mount. Participants who were fixated on using the boxes as containers were not able to solve the problem until they overcame this fixation and generated an atypical use for them.

2.1.2 The Two-Cord Problem

Maier's classic two-cord problem can also be understood as a demonstration of functional fixedness. In this problem, participants were taken to a room containing an assortment of objects, including poles, ring stands, clamps, pliers, extension cords, tables, and chairs. Two long cords were attached to the ceiling and reached all the way to the floor. Participants were instructed to tie the ends of these two strings together. The primary obstacle in this problem was the distance between the two cords, which exceeded participants' arm spans. If a participant held one cord in one hand, it was impossible to reach the other cord with their other hand. There were four solutions to this problem:

1) One cord is anchored to an object (such as a chair). The other cord can be pulled over to the anchored cord.
2) One cord is lengthened (e.g., by tying the extension cord to it) until it can be reached while holding the other cord.

3) One cord is held and the other cord is pulled closer using a pole.
4) A weight is tied to the end of one of the cords and the cord is swung like a pendulum. The swinging cord can be caught while the participant is holding onto the other cord.

Participants were studied until all four solutions were reached, or until failure. The fourth solution, the pendulum solution, was the one with which Maier was most interested and is the primary reason it is referenced in the literature on functional fixedness. In order to reach this solution, one must disregard conventional uses for household objects (e.g., pliers) and generate an unusual use for them (e.g., using it as a weight). Likewise, one must generate a novel function for the cord—swinging in the fashion of a pendulum. For participants that failed to generate the final solution, the experimenter offered a subtle hint in which he passed by the cord and set it in motion. Seeing the cord in motion facilitated solution for many of the participants, likely because, using Duncker's (1945) terminology, the hint highlighted the functional value of the solution being sought. That is, participants recognized that the problem required swinging the cord, and engaged in a search of their environment for an object that fulfilled this function. The hint bridged the gap between the solution and the participant's formulation of the problem. Interestingly, most of the participants that were able to solve the problem only after this subtle hint was given reported that they did not see the swinging cord. Rather, they experienced a sudden illumination of the solution in their consciousness.

2.1.3 The Circuit Problem

Glucksberg (1964) introduced a problem referred to as the circuit problem. In the original conception of this problem, participants were presented with an open circuit which consisted of two flashlight batteries, a switch, wiring, and a bulb, all of which were mounted together on a board. These items were arranged such that closing the circuit would turn the bulb on and signal successful solution of the problem. However, the default state of the switchboard left the circuit open, and the available wiring was not sufficient to close the circuit. Alongside the circuit, participants were presented with modeling clay and one of two screwdrivers. In one condition, the screwdriver was 9 inches long with a shiny blade and a handle that matched the colors of the wires in the circuit. In the other condition, the screwdriver was 3.25 inches long with a 1.5-inch blade and a wooden handle. The solution to this problem is to use the screwdriver in an unconventional way—as a conductor to complete the circuit. Functional fixedness was operationalized as the time the participant took to reach the solution. Participants shown the large screwdriver with a handle whose colors matched the wiring of the switchboard exhibited much lower functional fixedness.

2.1.4 Discussion of Functional Fixedness in Classical Insight Problems

In each of these classical insight problems, the successful problem solver must overcome an initial functional fixedness and generate a new or unusual use for at least one focal object. These problems demonstrate that functional fixedness can be manipulated in more than one way. In the candle problem, the experimenter manipulates the salient use of the target objects (the boxes) by either filling them with experimental stimuli or leaving them empty. This demonstrates that features of the object itself can have a profound effect on the uses that problem solvers are able to generate. The two-string problem, in contrast, did not manipulate the salient use of the target object. Rather, the experimenter highlighted the functional value of the solution. That is to say, the experimenter subtly hinted that any viable solution to the problem (once the three easier solutions have been exhausted) must involve setting one of the strings into a pendulum motion. With this knowledge, problem solvers shifted their approach to the problem and initiated search of the task environment for an object that could fulfill that function (the pliers). Similarly, the circuit problem did not manipulate the salient use of the target object. Rather, by incorporating a screwdriver with a long, shiny blade and a handle whose colors matched the wiring of the circuit, the experimenter subtly encouraged problem solvers to attend to features of the target object that facilitated generation of the atypical function (conduction) required to solve the problem. By induction, I reason that functional products in general facilitate functional fixedness while broken products do not. This is because a product functioning as usual is consistent with typical or conventional uses for the product. A broken product, by contrast, should not facilitate functional fixedness, and this prediction can be tested by comparing and contrasting the novelty of uses that people are able to generate for consumer products.

2.2 Representational Change Theory

A major update to Duncker's (1945) theoretical account of insight problem-solving was posited by Knoblich et al (1999) in their work on problem-solving using matchstick arithmetic. These authors asserted that problem solvers develop representations of problems. When faced with an impasse, they must change their problem representations in order to identify an effective solution procedure (Ohlsson, 1992; Fleck and Weisberg, 2004). This theory is called the representational change theory (Knoblich et al, 1999). Problem representations contain information regarding the perceptual grouping of elements in the problem environment as well as implicit and explicit constraints associated with the problem. They argue that in order to solve insight problems, problem solvers must change their initial problem representation by decomposing whole problem elements into parts and/or relaxing unwarranted problem constraints.

2.2.1 Chunking and Chunk Decomposition

After becoming familiar with a class of objects or events, people tend to perceive fixed patterns or constellations of their features. This process is referred to as chunking (Gobet et al, 2001). Described another way, a chunk is two or more bits of information which have been grouped together to form a single unit (Miller, 1956; Gobet et al 2001). Chunking enables humans to complete complex calculations that would otherwise not be possible due to limited information processing capacity. For example, novice chess players may view each chess piece individually, while expert chess players have been found to aggregate formations of chess positions together (De Groot 1946; Simon & Chase, 1973). These positional patterns, rather than their individual elements, become ‘chunks’ which can be operated on to facilitate complex calculations that would not be feasible to perform otherwise.

Chunking is an underlying cause of perceiving objects as whole objects. Given the complexity of visual environments, humans have developed a capacity to group visual information into meaningful chunks in order to facilitate navigation within these environments (Gobet et al 2001). The automatic grouping of features into objects was a central theme of research for the Gestalt psychologists, who referred to this phenomenon as Prägnanz. For the Gestalt psychologists, Prägnanz is a function of fundamental laws of perception (modernly referred to as principles, since their status as laws is subject to debate) including the principles of proximity, similarity, closure, continuity, and common fate (Wagemans et al 2012). Exactly how the brain combines features into perceptually cohesive objects is unknown, and is an important conundrum in cognitive science referred to as the 'binding problem' (Treisman, 1996). One can think of this automatic perceptual grouping as either arising from fundamental principles or laws of perception, or arising from some heretofore unknown cognitive mechanism. For the present work, it is sufficient to note that an automatic chunking process occurs which causes people to perceive objects as cohesive wholes.

Chunk decomposition refers to the disassembly of chunks into their component features (Knoblich et al, 1999; Gobet et al 2001; Wu, Knoblich, and Luo, 2013). Chunking can be helpful or unhelpful based on the context. Often, if a problem follows a structure of exploration-impasse-insight-execution (Poincaré 1908/1952), chunk decomposition will be a helpful strategy for solving the problem (McCaffrey, 2012). This idea is illustrated by experiments conducted by Knoblich et al (1999) in their research on insight problem solving with matchstick arithmetic.

In matchstick arithmetic, participants are presented with false arithmetic statements made by arranging matchsticks into roman numerals and other arithmetic operators (e.g. "=", "+", "-"). They are instructed to make the false arithmetic statement true by moving a single matchstick. Matchsticks cannot be discarded. An example problem follows:

In this simple problem, the solution is to move the leftmost matchstick to the right of the V, creating a statement that reads VI = III + III. Matchstick arithmetic is difficult due to implicit constraints that problem solvers bring to the table. However, it is also difficult because the matchsticks form fixed perceptual patterns which the brain chunks into symbols. Decomposing these chunks requires effort and intention, while the initial chunking is performed by the brain's perceptual systems automatically. Consider the following problem:

Problem:	VI = VIII + III
Solution:	XI = VIII + III

When two matchsticks are arranged diagonally facing opposite directions, with the bottoms of each stick adjacent to one another, participants automatically chunk these individual matchsticks into a 'V' symbol. Objectively, the participant has access to two matchsticks which can be arranged arbitrarily. Subjectively, the participant has access to one 'V' unit which can be operated on. This problem can only be solved by overcoming this biased perception and viewing the 'V' in terms of its elementary parts—two matchsticks which can be arranged as suited by the participant (in this case, into an 'X'). An interesting finding resulting from the problems studied by Knoblich et al (1999) is that once participants decompose a particular chunk (e.g., 'V', 'X') that chunk remains decomposed for subsequently presented problems. This facilitates transfer effects for that specific symbol. As stated in their paper, "Decomposing a number symbol like X into its component symbols \ and / has the potential to affect performance on any problem that involves *that* symbol" (p. 1543, emphasis added). It is unclear from their findings whether chunk decomposition in one problem transfers to a more general tendency to decompose chunks in subsequent problems. Instead, this paper addresses the question of whether a given chunk decomposed in an initial problem remains decomposed for subsequent problems using that same specific chunk. This topic will be discussed more in the section on transfer effects and examined empirically in Study 5.

The authors also found that matchstick arithmetic problems with ‘tight’ chunks, as opposed to ‘loose’ chunks, were more difficult to solve. They specify that tight chunks are composed of component parts which by themselves are not meaningful, while loose chunks are composed of meaningful component parts. In the context of matchstick arithmetic, ‘VIII’ is a loose chunk; it can be deconstructed into the meaningful units, ‘V’, ‘I’, ‘I’, and ‘I’, all of which have apparent value in this context. In contrast, ‘V’ and ‘X’ are tight chunks, because their dissolution yields diagonal lines which are not apparently meaningful (although they can be made to appear meaningful upon further examination). Furthermore, the tightness and looseness of these symbols are considered tight in part due to associations formed by prior experience with these symbols. While most people have had little or no experience separating ‘V’ and ‘X’ into parts, many people (particularly in Western culture) have experience separating ‘VIII’ into parts. The authors considered the symbols ‘+’ and ‘=’ to be intermediate on a scale between tight and loose.

Examining the functional fixedness literature with an eye focused on chunk decomposition reveals a history of decomposing objects as an effective intervention for functional fixedness. Glucksberg and Danks (1968) conducted an experiment using a modified version of the circuit problem. In this experiment, the objects were either labeled, not labeled, or labeled with differentiation. In the differentiated label condition, the screwdriver was labeled, “SCREWDRIVER: HANDLE, BLADE.” Simply listing the parts of the screwdriver was enough to significantly increase the number of participants that were able to solve the problem during a 5-minute window when compared with the other two groups.

McAffrey (2012) implemented the concept of chunk decomposition in an interesting and effective technique designed to reduce functional fixedness in problem-solving. This technique, the generic-parts technique, is a semi-algorithmic approach in which problem solvers ask a series of questions about the objects in a particular problem space until a solution is reached. First, the problem solver creates a parts diagram, with the whole object written at the top of the diagram. This object is then separated into parts, and these parts are written below the whole object, with lines pointing from the whole object to its listed parts. This diagram can be iterated indefinitely until all of the conceivable parts of an object can be listed. While creating the diagram, the problem solver continually asks two questions: 1) "Can this be decomposed further?" and 2) "Does this description imply a use?" By elaborating on objects and their parts in this manner, problem solvers are able to recognize otherwise obscure features of the objects being used to solve insight problems. Recognition of these obscure features enables the problem solver to overcome the mental obstacles to insight problem-solving caused by functional fixedness.

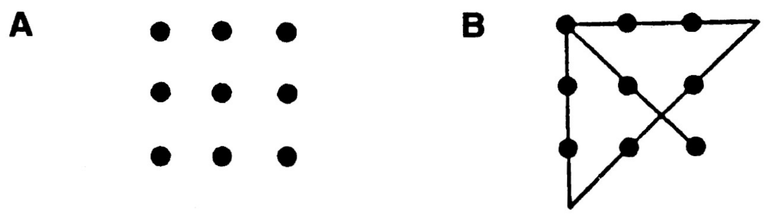
2.2.2 Tightness and Looseness

Tightness and looseness are critical concepts to the phenomenon of chunk decomposition. Tightness refers to the strength with which components of a chunk are grouped (Wu et al, 2013). Reciprocally, looseness refers to the weakness with which components of a chunk are grouped. Loose chunks consist of components that are themselves meaningful units. Tight chunks consist of components that are themselves not meaningful units. Generally, loose chunks are more easily decomposed than tight chunks. These relationships are further reinforced by stimulus familiarity. Components of tight chunks tend to be found bound together frequently in one's experience. Consider, for instance, a mug. Most mugs will be held as tight chunks, whose components (e.g. handle, rim) are not meaningful. Decomposing a mug into chunks is not only perceptually difficult, but it is also foreign to prior experience, because breaking a mug into component parts is an infrequent occurrence for most people when compared to breaking other objects into parts (e.g., thermoses).

2.2.3 Constraint Relaxation

Theory developed from research on both insight and non-insight problem-solving places an emphasis on the notion of problem constraints (Newell and Simon, 1972; Taylor 1975; Isaak and Just, 1995; Stokes, 2007; Moreau and Engeset, 2016). Constraints are limitations or specifications deemed appropriate for reaching a solution to a given problem. These constraints can be held implicitly or explicitly, and are deterministic of problem-solving. In other words, the constraints applied to a problem determine the potential solutions that consumers will generate. When these constraints are inappropriate, appropriate solutions will not be reached by the consumer. A key to solving many insight problems is to relax implicit constraints which are not specified by the problem itself, but are unconsciously adopted by the consumer, perhaps due to prior experience with similar problems (or in the case of functional fixedness, similar objects).

A classic example of the relaxation of implicit constraints is the nine-dot problem (Scheerer, 1963; Weisberg and Alba, 1981; MacGregor et al, 2001; Kershaw and Ohlsson, 2004). In this problem, participants are presented with nine dots arranged in a 3x3 grid. Participants are instructed to use four straight lines to strike through each of the nine dots in the grid, without lifting their pencil. This problem is made difficult because it cues an implicit constraint; namely, participants limit themselves to only drawing lines within the grid. This constraint is not specified in the problem instructions. Rather, participants “smuggle in” this constraint because a) prior experience with similar connect-the-dot problems do specify that lines should be drawn within a grid and b) the 3x3 grid creates a perceptual effect in which the mind automatically perceives a square circumscribing the nine dots. The nine-dot problem is impossible to solve with this implicit constraint—its solution can only be obtained by relaxing this constraint and drawing lines outside of the box.



In another classic insight problem, the matchstick problem, participants are instructed to use six matchsticks to create 4 equilateral triangles, with the explicit constraint that each side of each triangle be equal to the length of one match (Scheerer, 1963; Isaak and Just, 1995). Participants given this problem tend to adopt an implicit constraint, namely that the triangles should be constructed in a two-dimensional space. This constraint must be relaxed in order to reach the solution to the problem, which is to use the six matches to construct a three-dimensional pyramid.

Both the nine-dot problem and the matchstick problem require the relaxation of implicit constraints in order to reach their solution. This does not imply, however, that relaxing constraints always leads to creative problem-solving. The appropriate application of constraints can also be instrumental to problem-solving (Taylor, 1975; Isaak and Just, 1995; Moreau and Engeset, 2016). Indeed, it has been claimed that constraints are a necessary prerequisite for creativity (Stokes, 2007). For Duncker (1945), problem solution occurs when the problem-solver is able to ascertain the *functional value* of a solution, or the means by which a solution is effective. Recognition of the functional value associated with a problem cues the appropriate application of a constraint. In the candle problem, problem solvers determine that the solution requires a platform (constraint) and search the problem environment for an object that can be used for that purpose (box). Relatedly, Mehta and Zhu (2016) have found that activating a scarcity mindset in consumers reduces functional fixedness, because participants apply constraints (e.g., not being able to purchase new products) which forces them to come up with new ways to use products that they have already purchased. In a general sense, constraints are a critical component of problem solving, and both relaxing unjustified constraints and applying justified constraints can be instrumental to solving problems (Dahl and Moreau, 2007).

Matchstick arithmetic provides an illustrative context for understanding the role of constraints in problem solving. Problem solvers that are unfamiliar with matchstick arithmetic tend to smuggle in implicit constraints due to prior experience solving arithmetic problems. Recall the following matchstick arithmetic problem:

Problem:	IV = III + III
Solution:	VI = III + III

This particular problem violates what Knoblich et al (1999) refer to as the *value constraint*, which is a rule in standard arithmetic that states that numerical values on one side of an equation cannot be changed unless an equivalent compensatory change is applied to the opposite side of the equation. This constraint must be relaxed in order to solve the problem.

In a more difficult problem, additional implicit constraints must be relaxed:

Problem: I = II + II

Solution: I = III – II

This problem, in addition to violating the value constraint, violates the *operator constraint*, which specifies that arithmetic operators (e.g. "+", "-") cannot be arbitrarily deleted, introduced, or altered. Prior associations from solving arithmetic problems inhibit problem solvers from thinking about modifying the matchsticks that compose the "+" in this problem.

In this third problem, a third implicit constraint must be violated:

Problem: III = III + III

Solution: III = III = III

This problem violates the value constraint, the operator constraint, and the *tautology constraint,* which specifies that arithmetic functions should follow the form X = f(Y, Z), such that some calculation is called forth. The more constraints that need to be violated in order to solve the problem, the more difficult the problem becomes, as Knoblich et al (1999) demonstrate in their experiments. In their studies, participants were presented with matchstick arithmetic problems, each of which violated one of the three constraints outlined previously. They found that both frequency of solution and solution time increased as a function of a) the scope of the constraint used in the problem and b) constraint relaxation. In other words, problems that required the relaxation of more fundamental constraints, such as the tautology constraint, were more difficult to solve than problems that required relaxation of more surface-level constraints, such as the value constraint. Additionally, when participants relaxed a given constraint, that constraint stayed relaxed for subsequent problems, facilitating transfer from one problem to another.

Constraints are critical in the domain of creativity, and provide a framework for understanding the functional fixedness phenomenon. From a constraint relaxation account, functional fixedness is caused by prior experience ‘smuggling’ in overly narrow constraints regarding how objects can be used. For example, when working with a wagon, consumers may carry implicit constraints regarding how the wagon could or should be used. Some constraints may be that the wagon should be used for pulling heavy things, or that it should not be disassembled, or that it is a toy for children. Relaxing these constraints may be critical to using the product creatively and may even yield transfer effects for subsequently encountered products.

2.3 Creative Cognition and the Geneplore Model

Much of the research on creativity in consumer behaviour stems from the creative cognition approach to understanding creativity (Finke et al, 1992; Dahl et al, 1999; Dahl and Moreau, 2002; Bourroughs and Mick, 2004; Moreau and Dahl, 2005; Dahl and Moreau, 2007; Sellier and Dahl, 2011; Mehta and Dahl, 2019). This approach emphasizes the notion that creativity follows from cognitive processes that are germane to the general population, as opposed to a unique trait possessed only by creative geniuses. Furthermore, the creative cognition approach conceives of creativity as arising from a broad array of cognitive processes, as opposed to arising from a unitary mental process. In their Geneplore model (an abbreviation of generation-exploration), Finke et al (1992) separate the mental processes associated with creative cognition into two broad categories: generative and exploratory. Initially, creative cognition moves through a generative phase in which generative cognitions are prevalent. These include mental activities such as visual imagery, analogical transfer, synthesis, association, categorical reduction, memory retrieval, and mental transformation. Afterwards, creative cognition moves through an exploratory phase in which exploratory mental activities occur such as attribute finding, conceptual interpretation, functional inference, contextual shifting, hypothesis testing, and searching for limitations. While generative and exploratory processes are demarcated in the Geneplore model, the authors emphasize that these generative and exploratory processes can be, and often are, engaged in iteratively until a satisfactory creative product is attained.

The Geneplore model hinges upon a particular type of mental structure that the authors termed *pre-inventive structures*. Pre-inventive structures are internal representations such as "novel visual patterns, object forms, mental blends, category exemplars, mental models, and verbal combinations…[which are] largely uninterpreted at the time they are initially constructed" (p. 2; Finke et al, 1992). These mental structures are formed during the generative phase of creative cognition and contain emergent properties which can be investigated during the exploratory phase to yield a creative product. For example, Finke (1990, 1996) reports an example of a creative product developed by a participant using a visual imagery exercise. In this exercise, the participant was asked to mentally synthesize an arbitrary set of geometric shapes—a sphere, a half-sphere, and a cylinder—into an object that could be useful. Imagined combinations of each of these shapes constitute pre-inventive structures, containing emergent properties which can be reinterpreted to yield novel ideas. The creative product developed in this example was a hamburger maker which can be used to roll and flatten ground beef.

The Geneplore model marks a departure from information processing theories of problem-solving (Newell and Simon, 1972) which the authors describe as "based exclusively on highly constrained computational mechanisms" and a reduction of creativity to "strictly computational processes" (pp. 26-27; Finke et al, 1992). Indeed, the creative cognition approach in some sense represents a return to earlier Gestalt perspectives of creativity and problem solving (Duncker, 1945; Wertheimer, 1945). The centrality of emergent properties arising from pre-inventive structures in the Geneplore model as well as an emphasis on visualization is reminiscent of the Gestaltists' emphasis on whole structures in visual perception. Moreover, Finke (1989) asserts that perception should be understood in terms of principles as opposed to formal models, in line with the Gestaltists approach to understanding perceptual organization in terms of basic laws. Finke (1989) presents research which he uses to argue that mental imagery and visual perception follow the principles of perceptual, spatial, and transformational equivalence. That is to say, the processes underlying mental imagery and actual visual perception are the same, and the properties of imagined objects in the mind have a one-to-one correspondence with their real-world counterparts. This claim is consistent with the Gestalt claim that whole images are projected from the brain onto the visual field (Rock and Palmer, 1990).

2.3.1 Functional Fixedness Under the Geneplore Model

The creative cognition theorists view functional fixedness as a member of a class of fixation effects and conceive of it as a case of mental set. Smith (1995) describes a "mental rut" view of fixation in which thinking of an object in one way leads the mind into a mental rut. Once the mind has begun to think in a certain way about the object, additional effort to think about the object only serves to deepen the mental rut, making it more and more difficult to generate novel uses for the object. Under this view, when Duncker (1945) presented boxes filled with stimuli, participants became entrenched in a mental rut in which further elaboration on the uses for the boxes only lead to increased fixation on the containment function of boxes, making the platform function of boxes more and more elusive. Smith (1995) argues that incubation is effective at resolving functional fixedness because it allows the mind to forget what it was thinking about and begin solving the problem anew, away from the mental rut which it had been previously entrenched in. Additionally, the notion of pre-inventive structures may contribute to our understanding of broken products and, more generally, incomplete structures which can be manipulated, reinterpreted, reconstructed, etc. as a means of generating novel creative products. It may be that broken products have the characteristics of pre-inventive structures, which would help to explain the novel creative products that can be generated from them.

2.4 Information Processing Theory

The Gestalt school of thought did not persist for very long, perhaps because the leaders of this group of psychologists experienced political upheaval and even early deaths, including the death of Karl Duncker at age 37 (Rock and Palmer, 1990; Wagemans et al, 2012). Ultimately, most psychologists abandoned the behaviorist paradigm in favor of a paradigm that was amenable to cognitive phenomena such as insight problem solving. Many of the principles put forward by the Gestalt psychologists continue to influence psychology to this day (Rock and Palmer, 1990; Wagemans et al, 2012). However, the cognitive revolution in psychology changed the language that psychologists would use to study problem solving (Miller, 1956; Atkinson and Shiffrin, 1968; Newell and Simon, 1972). In contrast to the Gestaltists, who conceived of the human mind as being composed of whole structures that are *different* from the sum of their parts, the cognitivists asserted that the human mind is an information processing machine operating on whole structures which were *equal to* the sum of their parts *and their relations* (Miller, 1956;

Newell and Simon, 1972; Gobet, 2017). They argued that atomistic units of information could be arranged to form knowledge structures such as concepts, categories, schemas, frames, and fields, which could be operated on by the human mind in a manner similar to how information is processed by computers. One of the most influential theories of problem solving was developed by Newell and Simon (1972) under this paradigm.

According to Newell and Simon (1972), humans and computers alike are information processing systems which receive information from their environments as input, translate this information into symbols, perform operations on these symbols, and relay the outcome of these operations as output used to act on the environment. Formally defined, an information processing system (IPS) is “a system consisting of a memory containing symbol structures, a processor, effectors, and receptors” (Newell and Simon, 1972, p. 20). The term *symbol structure* refers to patterns of information that are chunked together and which make reference to some object or objects outside of the symbol structure. Symbol structures are immensely flexible. Letters, words, sentences, lists, programs, objects, etc. can all be held as symbol structures. The term *processor* refers to “a component of an IPS consisting of a) a (fixed) set of *elementary information processes* (eip’s); b) a *short-term memory* (STM) that holds the input and output symbol structures of the eip’s; c) an *interpreter* that determines the sequence of eip’s to be executed by the IPS as a function of the symbol structures in STM” (p. 20). The term *effectors* refers to mechanisms for information output (e.g., a human’s motor system) while the term *receptors* refers to mechanisms for information input (e.g., a human’s sensory system). By dynamically grouping or chunking information into symbol structures, IPS’s are capable of completing immensely complex mental operations with a limited short-term memory capacity and a handful of elementary information processes (e.g., symbol creation, symbol storage, discrimination between symbols stored in memory).

Under this theory, human behaviour can be understood in terms of programs. A *program* is "a set of rules and regularities that describe the sequence of eip's that [an IPS] executes as a function of the informational context it is in" (p. 31). Programs themselves can be held as symbol structures and implemented by the interpreter. The notion of programs can be illustrated by examining a subtype of programs called a production system. A *production system* is a series of conditional if-then statements. Newell and Simon present an example of a production system that a human IPS might use to walk across an intersection:

traffic-light red --> stop.
traffic-light green --> move.
move and left-foot-on-pavement --> step-with-right-foot.
move and right-foot-on-pavement --> step-with-left-foot.

In this example, the IPS works from left to right, checks if a statement is true or false, and proceeds iteratively until the task is completed. This example is quite simple, but similar programs can be written to describe much more complex behaviours. A large portion of Newell and Simon (1972) is devoted to written programs that an IPS can use to play chess, solve cryptarithmetic puzzles, and perform symbolic logic. Space does not permit the discussion of these topics in detail. Suffice it to say, similar programs can be conceived of for many of the problems studied in the problem-solving literature (Gobet et al, 2001).

Having defined the notion of an information processing system and the language that such systems use to complete tasks, Newell and Simon next elucidated the interaction between the IPS and the problem context. A *problem* can be defined as the situation in which "a person wants something and does not know immediately what series of actions he can perform to get it" (p. 72). Problem solvers are said to navigate task environments. The term *task environment* refers to "an environment coupled with a goal, problem, or task…for which the motivation of the [IPS] is assumed" (p. 55). Within the creative problem-solving literature more broadly, the task environment corresponds to the task instructions provided to problem solvers along with the physical setting in which the problem takes place (e.g., a table with boxes, candles, and matches, paired with instructions to mount the candle on a nearby wall). Newell and Simon (1972) posit that problem solvers confronted with a task environment construct a *problem space*, or "a representation of the task environment" (p. 59). A problem space is different from a problem representation. A problem representation refers to the way in which a problem solver construes of the problem within the problem space. The problem space is potentially immense, containing the set of all possible solution paths, problem representations, and methods that can be generated by the problem solver. While solving a problem, a problem solver may switch to a different problem representation. Problem representations are used to navigate information contained within problem spaces, which can exceed the limitations of short-term memory. Alternatively, the relationship between problem representations and problem spaces can be thought of as a subjective representation of the task environment versus an objective representation of the task environment which subsumes all conceivable subjective representations.

When an IPS confronts a task environment, it translates the environment as inputs and produces (simultaneously) a problem representation and problem space. Based on this problem representation, the IPS then selects a method, or "collection of information processes that combine a series of means to attain an end" (p. 91). The IPS then executes the method and determines the extent to which progress towards solution has been achieved. If solution has not been achieved, the IPS will either select a different method from the current problem representation, switch to a different problem representation, or abandon the solution attempt. For more complex problems, the IPS is capable of dividing a given problem into a collection of sub-problems. In an oft-used reductive approach to problem solving, a problem solver will subdivide a problem into elementary problems with are solved via mere recognition. For example, when confronted with an arithmetic problem such as 28 + 63, the problem solver might proceed by translating the problem into memorized problem-solution pairs: 8 + 3 = 11, 20 + 60 = 80, --> 11 + 80 = 91. Reduction is often effective for reducing the processing costs needed to solve a given problem.

Solution is said to be achieved when the current state of the problem space matches the goal state of the problem space. Most solution attempts begin by searching forwards from an initial state to a goal state; however, problem solvers can sometimes reach solution by attempting to search backwards from the goal state. Each successful operation performed within the problem space provides information that can be applied for successive operations within the problem space. A solution attempt may fail simply because the problem representation does not contain the method appropriate for reaching the solution.

2.4.1 Functional Fixedness in the Language of Information Processing Theory

Viewed through the lens of information processing theory, problem solving entails an IPS confronting a task environment. In order to make sense of the task environment, the IPS simultaneously selects a problem representation and constructs a problem space. This problem representation is a construal or interpretation of the task environment. This problem representation is composed of information stored as symbol structures and is used to navigate the problem space. Any given mental representation of a task environment entails information about the IPS's current state, goal state, appropriate operations, methods, and solution procedures which can be used to attain the goal state, and the resources available to the IPS. Dialectically, mental representations also entail information about what the current state is *not*, what the goal state is *not*, which operations, methods, and solutions are *not* appropriate, and which resources are *not* available to the IPS (Stokes, 2007). Objects traditionally employed in insight problem solving tasks are held in the problem representation as symbol structures. Generating novel uses for an object is difficult for problem solvers because each object is encoded as a symbol structure and embedded within a problem representation. This informational context presents constraints regarding how the object ought (and ought not) to be used to solve the problem. Thus, consistent with early theories of insight problem solving (Duncker, 1945), generating novel uses for an object often requires the selection of a different problem representation. By changing their problem representation, the problem solver is able to reconceptualize the symbol structure associated with the object featured in the insight problem. A different symbol structure embedded in a different problem representation enables the problem solver to consider different uses afforded by the object.

2.4.2 Object Functionality and the Unusual Uses Task

A change in the functionality of the object in an unusual uses task constitutes a change in the task environment presented to the problem solver. Consequently, changes to the task environment affect the problem solver's formulation of the problem space, problem representation, and symbol structure associated with the object. If the object is functional, the problem solver is free to use a problem recognition approach in which appropriate solutions are merely recognized. If the object is not functional, the problem solver will generate a problem representation which precludes search (within the problem space) for conventional object uses while promoting search for unconventional uses. In this circumstance, the generation of conventional uses is treated as an inappropriate operation—the mental representation of the problem contains a constraint against the generation of uses that are inconsistent with the object's dysfunctional state.

2.4.3 Problem-solving via Reduction to Recognized Solution in Consumption Contexts

Consumers may pursue a reductive strategy when interacting with broken products, just as they might pursue a reductive strategy to solving problems in other contexts. If a product does not facilitate conventional uses (i.e., if it is broken), the consumer may decompose the product into sub-parts, just as they might decompose a complex problem into sub-problems. The consumer will proceed with this decomposition strategy until meaningful sub-units of the product are found. This process is similar to reducing a problem into sub-problems until an elementary problem-solution association is recognized. These sub-parts then serve as meaningful units for generating product uses (McAffrey, 2012). This process may continue until decomposition fails to yield meaningful sub-units. For the unmotivated or uncreative consumer, the broken product in its entirety is viewed as containing no meaningful sub-units, and has already been reduced to its most meaningful unit in the eyes of the consumer. In this case, the product is treated as an elementary unit. The consumer recognizes an elementary product-use association (broken object—trash) and throws the object in the garbage.

2.4.4 Compatibility of Gestalt Theory and Information Processing Theory

The development of Information Processing Theory (IPT) induced a revolutionary paradigm shift in psychology (Miller, 2003). For psychologists studying insight problem solving, the transition from a Gestalt paradigm to an information processing paradigm was much less dramatic. Indeed, Simon (1986) viewed information processing theory and Gestalt accounts of problem solving as compatible accounts spoken with different vocabularies. Moreover, IPT implemented the notions of problem representations and representational change that were prominent in Gestalt accounts of insight problem-solving (Duncker, 1945; Wertheimer, 1945; Newell and Simon, 1972, Knoblich et al, 1999). Research on insight problem-solving can more or less be stated using either Gestalt or IPT vocabulary, although Gestalt theory places a heavier emphasis on restructuring of the problem representation while IPT places a heavier emphasis on information search (Simon, 1986; Ohlsson, 1984). This point is contentious, however, with some theorists criticizing IPT as being reductive or overly mechanistic (Finke et al, 1992; Wertheimer, 1985). In this paper, I have chosen to emphasize the compatibility of both schools of thought, and view IPT as a compromise between retaining Gestalt insights into problem solving and offering a more precise and parsimonious framework with arguably greater empirical support and explanatory value.

2.5 The Paired Constraint Model

Stokes, an artist-turned-theorist, developed the paired constraint model as an extension of Newell' and Simon's (1972) information processing model in order to understand creativity in artistic domains (Stokes, 2001, 2007, 2011, 2014, Stokes and Fisher, 2005). Scientists and artists have been studied copiously by creativity researchers (Runco and Albert, 2010). Intuitively, one might expect that the mechanisms underlying creativity in science to be different from those underlying creativity in art. However, Stokes offers an elegant integration of both domains through her development of the role of constraints in creativity. Building upon Newell and Simon (1972), Stokes notes that artists generate creative products by self-imposing problems. These problems are subject to the same structure as those studied in research on problem-solving in psychology. They consist of initial states, operators, and goal states, each of which can vary on a continuum between ill-structured and well-structured. Moreover, the problems that artists navigate can be understood in terms of task environments cuing problem representations within a problem space (Newell and Simon, 1972). Individual artists, as well as schools of artists, construct domains by applying constraints which restrict the problem space. These constraints can be observed when attempting to categorize movements or genres of art. For example, a repeated rhythm might establish the basis of a musical genre; a restricted medium might define a style of art; a consistent structure might establish a musician's signature sound. Constraints define domains, which are "well-developed areas of expertise with consensual performance criteria" (p. 109, Stokes, 2007). Crucially, Stokes emphasizes that constraints are not singular, but instead "come in pairs" (p. 109, Stokes, 2007). Constraints are thus understood in terms of constraint pairs. One constraint of the pair precludes search within a space; the other constraint of the pair promotes search within a space. Problems that require a novel response—novelty problems—contain three characteristics. First, they must be ill-structured or incompletely specified. Second, solution of the problem must require the strategic selection of paired constraints. Third, this constraint pair should be one which structures the problem space such that search among "reliable, expected responses" is precluded while search among "risky, surprising ones" are promoted (p. 108). Under this view, the generation of novelty follows from the way that a problem is structured. At the individual level, novelty problems inevitably lead to novel solutions (Stokes, 2007). For Stokes (2011), novelty is a function of variability; low variance surrounding an idea coincides with conventional or stereotypical responses, while high variance surrounding an idea coincides with novel responses. Novelty problems lead to novel responses by increasing the variability of ideas generated in response to the problem.

2.6 Overview of Research on Functional Fixedness

Functional fixedness can be placed into a class of effects called fixation effects (Finke et al, 1992, Smith and Blankenship, 1991; Chrysikou and Weisberg, 2005). Other members of this class of fixation effects include the anchoring and adjustment heuristic, the tip-of-the-tongue phenomenon, priming effects, and mental set (Luchins, 1942; Finke et al, 1992). Broadly, fixation has been defined as “a counterproductive use or undesirable effect of prior knowledge” (Smith, 1995, p. 234). In the context of new product development, fixation effects have been referred to using the term *design fixation* (Jansson and Smith, 1991). Research in this area has found that designers who are presented with example designs prior to developing their own novel designs tend to not deviate markedly from the design they were presented. In one experiment, engineering students were asked to design a bike rack for a vehicle (Jansson and Smith, 1991). Half of the students were shown an example design of a top-mounted bicycle rack incorporating rails and suction cups, while the other half were merely given written instructions. The authors found that there was a significant difference between groups in regards to the number of designs that featured top-mounted bicycle racks, rails, and suction cups, indicating that the students provided with an example design fixated upon the example design that they were given. Similarly, research asking people to draw an imaginary alien species has found that people tend to fixate on humanoid figures when developing their designs (Ward, 1994). Functional fixedness is conceptually distinct from other fixation effects. Notably, functional fixedness is a fixation on object uses, as opposed to fixation on solution procedures, numerical values, design elements, or distractor items in memory tasks (Smith and Blankenship, 1989; Beda and Smith, 2018). Functional fixedness can be differentiated from mental set by noting that, under the information processing paradigm, functional fixedness refers to fixation on elements of the initial state while mental set refers to fixation on operators which can be applied to the initial state as a means of reaching the goal state (Newell and Simon, 1972).

Previous research has identified several variables related to functional fixedness. It has been shown that this psychological tendency develops naturally during maturation, typically around age six or seven (German and Defeyter, 2000). Classical research on problem solving considers the overcoming of functional fixedness to be coincident with the reformulation of a problem. Initially a person approaches the problem with an incorrect or incomplete representation of the problem, and the correct representation of the problem manifests in a solution (Fleck and Weisberg, 2004). Research by McCaffrey (2012) has shown that innovative solutions often involve the recognition of an obscure feature of a problem and the subsequent construction of a solution based on that obscure feature. Similarly, educators in the domain of engineering have found success employing 'product dissection' activities to help engineering students develop more creative product designs (Grantham et al, 2013; Toh et al, 2014). Elaboration and re-encoding have been shown to be efficacious in reducing functional fixedness (Ohlsson, 1992). Furthermore, chunk decomposition has been shown to facilitate innovative problem solutions (Knoblich et al 1999). Likewise, time delay has been shown to be effective for alleviating functional fixedness (Adamson and Taylor, 1954). Often, problem-solvers will initially fixate on features of the problem and, after a delay, will approach the problem with a focus on different features. Indeed, this account has been put forth as an alternative account to the incubation phenomenon, which states that the unconscious mind works to solve problems during resting periods (Poincaré, 1908/1952; Smith and Blankenship 1991; Woodworth and Schlosberg, 1954). Röer, Bell, and Buchner (2015) found that uses generated for a set of 15 objects were more creative when participants were given a wilderness survival scenario as opposed to a moving scenario. This provides further evidence that changing the task environment causes changes in the uses that problem-solvers are able to generate for objects.

2.6.1 Functional Fixedness in Children

Research into the way that children solve problems provides insight into the phenomenon of functional fixedness. For example, Defeyter and German (2003) conducted an experiment investigating this phenomenon with children ages 5-7. Each child was presented with a problem: dislodge a stuffed animal from a long, thin tube using one of six objects (a pencil, a plastic straw, a ping pong ball, a ruler, a pad of paper, and a cup). Of these objects, only the pencil was suitable for providing a solution, as the other objects were either too short to reach the stuffed animal or too wide to fit into the tube. Half of the children were shown a demonstration for the pencil (writing on the paper) and the straw (drinking water from the cup) while the other half were not given any demonstration. Interestingly, this manipulation of functional fixedness significantly increased median solution time for the 6- and 7-year-olds, but had no discernable effect for the 5-year-olds. This held true even for a conceptual replication of the experiment that used unfamiliar objects (a magnet rod and a glass holder) as the demonstration stimuli.

2.6.2 Functional Fixedness Across Cultures

Research suggests that functional fixedness occurs across cultures. Indeed, German and Barrett (2005) observed functional fixedness in the Shuar of Ecuador, an Amazonian tribe that has existed separately from industrialized society for thousands of years. The Shuar are hunter gatherers that are unfamiliar with many of the technologies common in industrialized areas, although they have been known to use technologies such as machetes, axes, shotguns, and fishing hooks. German and Barrett chose to study functional fixedness within this group of people using objects that were familiar to them. Specifically, they used the box task (German and Defeyter, 2000) and the spoon task. In the box task, participants are instructed to create a tower high enough to reach a perch on which a fictional character is trapped. Participants are provided with a cardboard box, six Styrofoam cubes, a battery, a pencil eraser, and a rubber ball. The solution to this problem is to use the cardboard box as a platform for a tower made out of the other objects. Initially, participants tend to attempt to solve this problem by stacking up the Styrofoam blocks, but these blocks are not tall enough to reach the fictional character, who has been affixed to a wooden peg on a wall. The cardboard box must be used as a platform for the Styrofoam cubes in order to solve the problem. In the spoon task, participants are given the problem of creating a bridge for a fictional character to cross a river. Participants are provided with a spoon, two Styrofoam blocks (representing the sides of each river), a cup filled with rice, a small plastic cup, a lollipop stick, a Ping Pong ball, and an eraser. The solution to this task is to use the spoon to bridge the gap between the two Styrofoam blocks. Critically, participants were randomly assigned to a baseline condition or a function demonstration condition. In the baseline condition, the objects for each task were laid out without any suggestion as to how they should be used. In the function demonstration condition, the critical objects for each problem were arranged in such a manner that a particular use for each object was made salient. For the box task, the box was filled with the Styrofoam blocks; for the spoon task, the spoon was placed within the cup filled with rice. The participants assigned to the function demonstration condition exhibited a marked delay in the first use of the critical object for each task (i.e., box, spoon).

2.7 Novel Use Generation

Importantly, functional fixedness is relevant for the unusual uses task (UUT), one of the most prominent measures of creativity in the psychological literature (Guilford, 1967; Torrance, 1966). In this task, participants are asked to list as many uses as they can think of for an everyday object, such as a newspaper or a brick. The UUT was included among the battery of tests referred to as the Torrance Tests of Creative Thinking (TTCT; Torrance, 1966; Kim, 2006). Traditionally, the uses generated by participants were scored on four dimensions based on theorizing by Guilford: fluency, flexibility, elaboration, and originality (synonymous with novelty; Guilford, 1967). Fluency refers to the number of uses generated by a participant. Flexibility refers to the variability in the responses generated by a participant, operationalized as the number of categories to which a participant's set of uses could be assigned to. A response rated high in flexibility would contain uses that are remotely associated with one another, belonging to several separate categories, while a response rated low in flexibility would contain uses that are proximally associated with one another, belonging to only a few categories. Elaboration refers to the level of detail included in each use generated. Originality (or novelty) refers to the statistical frequency of ideas; uncommon ideas are considered to be original and common ideas are considered to be unoriginal. In the context of the TTCT, novelty can be indexed against a database of tens of thousands of uses that have been generated from the test.

This approach to measuring novelty is well-suited to studying creativity as a personality trait or as a means of measuring creativity in educational contexts, but is perhaps less suited to social psychological research (Amabile, 1982). Moreover, the measurement of novelty using statistical frequency leads to an untoward relationship between the novelty of the participant's response and the number of participants sampled. For this and other reasons, research under the creative cognition and social psychological paradigms favor the measurement of novelty using the consensus of independent expert judges (Amabile, 1982; Stokes, 2011). Likewise, the present work analyzes the novelty of responses to the UUT by having expert judges subjectively evaluate the novelty of responses within each data set on scale of 1 (not novel at all) to 7 (extremely novel). Because I am primarily interested in consumers' ability to generate novel uses for consumer products, in contrast with functionally fixed use generation, this measure of novelty is the primary dimension of interest for the UUT. I control for fluency by measuring average novelty within each participant's response set. Elaboration is not measured, as this dimension is more closely associated with persistence than novelty (Nijstad et al, 2010). In contrast, novelty and flexibility under the divergent thinking paradigm are closely related to one another and ought to be positively related to the subjective measures of novelty studied in the creative cognition and social psychology paradigms. Note that while the UUT is often referred to as a test or task, within the problem-solving paradigm it fulfills the inclusion criteria for classification as an ill-defined problem. Ill-defined problems are problems which have a myriad of potentially satisfactory solutions as well as ambiguous initial states, means of achieving solution, and solution criteria (Moreau and Engeset, 2016). Ill-defined problems afford divergent thinking while well-defined problems afford convergent thinking, which makes the UUT an appropriate measure of novelty generation.

2.8 Broken Products and the Unusual Uses Task

Consumers hold strong associations for familiar objects' most conventional functions. These functions are highly salient, having been reinforced consistently and repeatedly over time (Stokes, 2007). If a product is unable to perform its conventional function, the consumer is precluded from being able to produce conventional uses for the object and must instead generate new ones. This is precisely the scenario that occurs when an object becomes broken. The consumer is unable to use the broken product in a conventional manner and must generate novel uses for it. I use the term *broken* to refer to a product whose functionality has decreased through damage or deterioration. I can thus posit the following hypothesis:

H_1: Responses to the unusual uses task will be more novel for an object that is broken than for an object that is functional.

2.9 The Role of Chunk Decomposition in Novel Use Generation

When considering chunk decomposition in tandem with functional fixedness, prior experience serves to reinforce salient uses associated with a given object as well as inertia towards decomposing the object, both of which will be obstacles to novel use generation. Conversely, decomposing an object may decouple the object from the network of information in which it was previously imbedded. This necessarily precludes the transfer of functions associated with the object in memory. According to this line of reasoning, chunk decomposition is an effective strategy for overcoming functional fixedness because it blocks the negative transfer required for functional fixedness to take place. Previously, I hypothesized that consumers would generate more novel uses for products that are broken. This may be because broken products are perceived as loose chunks rather than tight chunks, and these loose chunks possess properties not unlike those possessed by the pre-inventive structures described by Finke et al (1992). This leads to the following hypothesis:

H_2: Greater novelty of responses to the unusual uses task when the object is broken will be mediated by decomposition of the product into its component parts.

2.10 Chunk Decomposition and Recycling

Presumably, consumers have a propensity to throw away products that they do not perceive as useful (Trudel and Argo, 2013) and facilitating the generation of novel uses for products may alleviate this behaviour. Consumer recycling behaviour has been shown to depend critically upon the fluency of the recycling decision (White et al, 2011). Mentally decomposing products into parts may make the process of recycling more fluent because recycling compound products necessarily entails breaking products into components and placing them into bins according to the material make-up of these components. Furthermore, it has been proposed that chunks which are decomposed in one task will remain decomposed for subsequent tasks (Knoblich et al, 1999). Therefore, I posit the following hypothesis:

H_3: Performing the unusual uses task for a broken product will increase the likelihood of recycling that product.

2.11 Analogical Thinking and Transfer Effects

Thorndike (1913a, 1913b) discovered in his experiments on animal problem-solving that animals performed better when solving problems similar to problems they had solved in the past. According to his identical elements hypothesis, problem solvers transfer information about a previously encountered problem to a new problem as a function of the problems' shared features. In the problem-solving literature, this phenomenon is referred to as analogical transfer. In analogical transfer, problem-solvers first access a problem from memory which is deemed similar to the problem at hand. The previously encountered problem is referred to as the *source problem*, and the problem at hand is referred to as the *target problem* (Novick, 1988). If the problem solver is able to identify a source problem which is structurally similar to the target problem, they may be able to apply this analogical transfer to successfully solve the target problem. In doing so, they are able to solve the target problem without the resource intensive development of a new solution procedure.

Analogical transfer takes place across three stages: access, mapping, and transfer (Herzenstein and Hoeffler, 2016). In the access stage, problem solvers seek to identify and retrieve a suitable source problem from memory. In the mapping stage, the structural elements of the source problem are indexed to the structural elements of the target problem in order to establish relationships between them. In the transfer stage, information from the source problem is applied to the target problem based on the relationships established in the mapping stage. Surface level similarity between problems is not an optimal means by which to pair source problems with target problems. This is because surface level features do not necessarily correspond with solution procedures.

For example, consider a problem posited by Duncker (1945) called the radiation problem. The radiation problem is stated as follows: “Given a human being with an inoperable stomach tumor, and rays which destroy organic tissue at sufficient intensity, by what procedure can one free him of the tumor by these rays and at the same time avoid destroying the healthy tissue which surrounds it?” (p. 1). The solution to this problem is to aim several small rays of radiation at different angles, each of which converge upon the tumor. The total amount of radiation will be sufficient to destroy the tumor, but because each ray is sent through a different portion of the tissue, only the tumor is destroyed. Gick and Hollyoak (1983) decided to use the radiation problem as a target problem in an experiment on analogical transfer. Before being given the radiation problem, participants were asked to read an analogous story based on a fictional military operation. In this story, a general is attempting to capture a fortress with several roads emanating from it. Scattered across each road are mines which will explode if too many soldiers attempt to cross them, making a largescale direct attack impossible but allowing passage for small groups of soldiers. The general decides to separate his army into small groups and simultaneously approach the fortress from each of its several roads, leading to the successful capture of the fortress. The authors discovered that participants presented with this story prior to approaching the radiation problem were significantly more likely to solve the problem. Participants were especially likely to solve the problem if they were told that the story they read would help them to solve the problem. This story provides an effective analog for the radiation problem because its structure—and its implied solution procedure—is the same. That is, both problems (capturing the fortress and destroying the tumor) require an approach from several angles, each of which converge upon the target.

Experts tend to be better at analogical transfer than novices because they are more likely to choose analogs based on both structural features and superficial features, while novices tend to focus solely on superficial features (Novick, 1988). Analogical transfer based on superficial features may not be helpful at all because superficial features do not convey information regarding solution procedures. Applying Duncker's (1945) terminology, superficially similar source problems do not contain the functional value of the solution for the problem at hand. When the appropriate analog is selected, however, the functional value of the solution may be readily applied and facilitate solution of the target problem. When an appropriate analog is chosen, this leads to positive transfer, which is the effective application of information from a source problem to a target problem (Novick, 1988). When an inappropriate analog is chosen, this leads to negative transfer, which is the ineffective application of information from a source problem to a target problem (Novick, 1988). Indeed, choosing the incorrect analog can be detrimental to problem solving.

Structural features of problems are represented abstractly by problem solvers. This phenomenon has been referred to using a variety of terms and theoretical perspectives, including problem formulation (Duncker, 1945), problem representation (Knoblich et al, 1999), problem spaces (Newell and Simon, 1972; Stokes, 2007; Moreau and Engeset, 2016), and problem schemas (Gick and Hollyoak, 1983; Chen and Mo, 2004). Evidence from the literatures on functional fixedness, insight problem solving, analogical transfer, and others bolster the notion that problem solvers develop abstract representations of the problems with which they interact (Novick, 1988; Gick and Holyoak, 1983; Ohlsson, 1984; Nokes, 2009). Furthermore, these representations can be modified during solution attempts, and can be carried into subsequent problems. This account helps to explain instances in which experience on one task can improve performance on subsequent tasks of a similar nature (Beaty and Silvia, 2012). If problem solvers can build a generalized schema for a class of problems sharing structural characteristics, they can use this general framework to solve a litany of problems sharing these characteristics. Likewise, this account helps to explain why insight problems can be so difficult. Insight problems tend to facilitate negative transfer; problem solvers attend to superficial features of these problems and draw upon analogous problems from prior experience which will not be useful for solving the target problem. For example, the nine-dot problem prompts participants to draw upon their representations of connect-the-dot problems from past experience. Using connect-the-dot problems as an analog to approach the nine-dot problem is detrimental to finding a solution, because the nine-dot problem requires problem solvers to draw their lines beyond the dots, while connect-the-dot problems typically require the problem-solver to terminate lines at dots.

The precise conditions under which analogical transfer occurs are not germane to the present work. A source problem and a target problem can be superficially similar, structurally similar, or literally similar (having both superficial and structural similarity; Nokes, 2009). The transfer effects which I will study will occur in the context of two literally similar tasks which are presented subsequently and are both structurally and superficially similar. Moreover, the mere fact that two problems are presented in succession is likely to yield transfer effects due to the first problem's accessibility in memory (Moreau and Engeset, 2016). Because the present work examines transfer effects between two literally similar problems, I predict that information which participants learn during the initial UUT will be applied to a subsequent UUT. Namely, I predict that participants that relax a constraint (e.g., this object ought not be disassembled) for one object in an UUT will relax that same constraint in a subsequent UUT. In this manner, I expect that generating uses for a broken product will increase the novelty of uses generated for a subsequent product. Stated formally:

H_4: Performing the unusual uses task for a consumer product that is broken will lead to more novel responses in a subsequent unusual uses task.

2.12 Paired Constraints and the Task Environment

Changes made to the task environment may differ in important ways from changes made to the object of the UUT. For instance, a change in the environment is not a direct manipulation of chunk decomposition. Following the paired constraint model (Stokes, 2007), a change in the environment which precludes search among conventional product uses while promoting search among unconventional product uses may motivate chunk decomposition as consumers engage in an exploratory search of the problem space. Or, it may facilitate novel use generation without chunk decomposition. Testing the paired constraint model by manipulating it from two different angles (the object and the task environment within which the object is imbedded) will provide information regarding whether problem representations possessing the attributes described by Stokes (2007) lead to increased novelty directly, indirectly via chunk decomposition, indirectly via some other pathway, or not at all. However, given the critical roles that chunking and chunk decomposition have played in the studies presented thus far as well as the prominence of these variables in the successful interventions of functional fixedness found to date (e.g., Knoblich et al, 1999), I suspect that chunk decomposition would at the very least be causally implicated in any observed effects of an environmental manipulation on novel use generation. Assuming the paired constraint model and my application of it is correct, the following hypotheses are implied:

$H5_a$: Participants will generate more novel uses for a product when environmental factors preclude search among conventional uses while promoting search among unconventional uses.

$H5_b$: This effect will be mediated by chunk decomposition.

Each of the hypotheses developed in this chapter is presented in Table 1. These hypotheses are documented in pre-registrations which can be found in Appendix C. Experiments designed to test the hypotheses are reported in Chapters 3 and 4.

Number	Hypothesis	Study
1	Responses to the unusual uses task will be more novel for an object that is broken than for an object that is functional.	Studies 1-5
2	Greater novelty of responses to the unusual uses task when the object is broken will be mediated by decomposition of the product into its component parts.	Studies 1-5
3	Performing the unusual uses task for a broken product will increase the likelihood of recycling that product.	Studies 6-7
4	Performing the unusual uses task for a consumer product that is broken will lead to more novel responses in a subsequent unusual uses task.	Study 5
5a	Participants will generate more novel uses for a product when environmental factors preclude search among conventional uses while promoting search among unconventional uses.	Study 4
5b	This effect will be mediated by chunk decomposition.	Study 4

Table 1. List of hypotheses.

Chapter 3: Experiments on Broken Products and Novel Use Generation

3.1 Overview of Experiments

In order to test the hypotheses presented in this thesis, I conducted a series of experiments with human participants. In Study 1, I examined whether consumers are better able to generate novel functions with a wagon that is broken versus a wagon that is not broken. In Study 2, I tested the role of chunk decomposition on novel use generation by comparing the novelty of uses generated for a whole wagon, a broken wagon, and a disassembled wagon. In Study 3, I further explored these relationships by comparing the novelty of uses generated for functional whole wagons, broken whole wagons, functional disassembled wagons, and broken disassembled wagons. In Study 4, I tested a moderated serial mediation model based on my theorized causal process. This study employed a manipulation of the task environment to demonstrate that the underlying reason for observing more novel uses for both broken and disassembled products is the construction of a problem representation which promotes search among unconventional product uses while precluding search among conventional product uses.

3.2 Study 1

Study 1 was conducted to test Hypothesis 1, which predicts that the functionality of a product will have an effect on the novelty of uses that participants are able to generate for it, with more novel uses being generated for products that are broken. Additionally, I sought to explore whether generating novel uses for a dysfunctional product (a wagon), as opposed to a functional one, would have a downstream impact on consumers' ability to generate novel uses for an unrelated product (a pair of scissors). Furthermore, I tested Hypothesis 2, which predicts that uses will be more novel for a broken product as a result of participants viewing the product in terms of its parts.

3.2.1 Procedure

A total of 174 participants took part in this study via the Amazon Mechanical Turk (MTurk) platform. One participant was removed due to suspicion of non-human responding (unintelligible text) and another participant was removed due to missing data, leaving 172 (51% female) participants. Participants were assigned to one of two conditions: the *functional* condition or the *broken* condition. Participants were then given the following instructions: "Imagine that you are pulling a bright red wagon. You look at the wagon and notice that the wheels are [turning smoothly/are not turning at all]. Please list as many uses for the wagon as you can think of." All participants were also asked to list as many uses for a pair of scissors as they could think of. The order of both tasks was randomized such that half of participants performed the scissors task first and half performed the wagon task first. Finally, participants were given a manipulation check and asked to respond to several demographic measures.

3.2.2 Analysis

Responses were coded by two judges who were blind to the hypotheses and conditions of the study. First, each judge read through participants' responses to the UUTs. They identified 64 unique uses generated by participants for the wagon and 82 unique uses generated for the pair of scissors. Common uses included hauling objects, using the wagon as decoration, and using it for storage. Each judge then examined each item in the list of actions and rated its novelty based on a seven-point scale (anchored at 1 = Not novel at all, 7 = Extremely novel). Afterwards, the judges compared their ratings and consolidated their responses, resolving any discrepancies via discussion. In order to explore whether participants differed in their tendency to decompose the wagon into chunks during the UUT, a third judge was commissioned to evaluate each response set based on whether or not it contained a use requiring the decomposition of the wagon into its component parts. This represents an operationalization of the chunk decomposition construct.

3.2.3 Results

As measures of novelty, I examined both the average novelty score of each response set and the top novelty score of each response set. I include results for both measures, but place greater emphasis on average novelty as a metric as this measure controls for the number of uses generated by each participant. As predicted, participants in the broken product condition yielded higher average novelty for the wagon task (M_{broken} = 1.90, $M_{functional}$ = 1.53, $t(162.33) = 2.94$, p = .004). These results were robust for top novelty as well (M_{broken} = 3.13, $M_{functional}$ = 2.53, $t(169.88) = 1.92$, $p = .06$). Neither average nor top novelty scores differed significantly across conditions for the scissors UUT (ps > .05). I did not detect any differences in fluency, or the number of uses generated, between conditions for either the wagon or the scissors (ps > .10).

I used mediation analysis in order to test whether my measure of part-whole cognition served a mediating role in the effect of product functionality on creativity. Indeed, the indirect effect of product brokenness on novelty via chunk decomposition was significant ($\beta = .11$, SE = .05, $p = .03$, 10,000 bootstraps). The total effect for the model was significant ($\beta = .37$, SE = .13, $p = .003$). The A path, or the effect of product functionality on chunk decomposition, was significant ($\beta = .17$, SE = .07, $p = .008$). The B path, or the effect of chunk decomposition on average novelty, was also significant ($\beta = .65$, SE = .15, $p < .001$). The C path, or the direct effect of product functionality on creativity controlling for chunk decomposition, was also significant (β = .25, SE = .15, p < .001), indicating that there may be other variables mediating the effect which are not present in the model.

3.2.4 Discussion

Study 1 provided evidence in support of my hypothesis (Hypothesis 1) that consumers are able to generate more novel uses for products that are broken than for products that are functional. Moreover, I provided process evidence that this occurs because consumers mentally construe broken products as a series of components (Hypothesis 2). That is to say, they resist viewing the product in terms of chunks and more readily decompose it into component parts. In contrast, I argue that consumers construe functional products as whole products. Construing products as a series of components provides consumers with comparatively more elements that can be used for creative ideation and synthesis. Studies 2 and 3 examined this proposition further.

3.3 Study 2

Study 1 provided evidence that consumers mentally construe broken products as being composed of a series of parts. Study 2 was designed to examine whether providing consumers with a product that was separated into parts would have similar effects (relative to a product that was merely dysfunctional) on consumers' ability to generate novel uses for the product. To facilitate comparison between study results, I again used a wagon as the product for analysis. However, I used a brick task, as opposed to a scissors task, to measure spillover creativity following creative ideation around the wagon. Moreover, I included two additional measures of creativity: a Remote Associates Test (RAT; Mednick, 1962; Bowden & Jung-Beeman, 2003) which was designed to measure convergent thinking, and a measure of openness to creative products (Mehta et al, 2017).

3.3.1 Procedure

A total of 338 participants took part in this study via the Amazon Mechanical Turk platform. Eleven of these responses were removed due to indication of non-human response, leaving a final total of 327 participants (51% male). Participants were randomly assigned to one of three conditions: the functional condition, the broken condition, and the disassembled condition. Participants were asked to imagine that they owned a wagon that was either functional, broken, or disassembled, and were provided with a picture of a wagon fitting that description (Figure 1). Participants were then asked to list as many uses for the wagon as they could think of. Following this exercise, participants were asked to list as many uses as they could think of for a brick. They were then shown instructions for the RAT. Each participant completed 10 RAT items and were given 30 seconds for each item, after which the screen would automatically move to the next page. One item, for example, was “boot/summer/ground” with the correct response being “camp.” After completion of the RAT, participants were given a measure developed by Mehta et al (2017) to measure openness to creative products. Participants were asked to take the perspective of a t-shirt manufacturing company deciding which t-shirt designs they should produce next. Participants were told that “only the best, most creative designs should be submitted” for consideration. These designs had been previously pretested such that five of them were considered high in originality but low in social normativity; the other five were considered to be low in originality but high in social normativity (Mehta et al, 2017).

For each t-shirt design, participants were asked “How willing are you to submit this t-shirt design?” (anchored at 1 = Not willing at all, 7 = Extremely willing). Finally, participants responded to a manipulation check and several demographic measures.

Figure 1. Wagon images for Study 2. Displays stimuli for the functional wagon condition (left), the broken wagon condition (middle) and the disassembled wagon condition (right). Original images were created by Park (2007).

3.3.2 Analysis

Independent judges identified 83 unique uses listed by participants during the wagon UUT and 93 unique uses listed by participants during the brick UUT. They assigned novelty ratings for each of these uses, with discrepancies resolved via discussion. Additionally, these judges assigned appropriateness scores to each use using a scale from 1 (Not appropriate at all) to 7 (Extremely appropriate), with discrepancies resolved via discussion. Responses to the t-shirt scenario were separated based on whether the designs were low in originality or high in originality. Willingness to submit high originality, low normativity designs was averaged into an index measure. Likewise, willingness to submit low originality, high normativity designs was averaged into an index measure. This resulted in both a measure of preference for low novelty products and a measure of preference for high novelty products. Correct responses for the RAT items were assigned a value of 1, while incorrect responses were assigned a value of 0. These scores were then summed to represent a measure of convergent thinking for each participant, with scores ranging from 0 to 10. I analyzed differences between condition for average novelty, top novelty, fluency, and flexibility using one-way ANOVAs.

3.3.3 Results

For the wagon task, a one-way ANOVA revealed that average novelty differed across condition ($F(2, 323) = 54.4$, $p < .001$). Planned contrasts indicated that participants in the broken condition yielded more novel responses on average than those in the whole condition ($M_{broken} = 3.98$, $M_{whole} = 2.60$, $t(323) = 10.26$, $p < .001$) and the parts condition ($M_{parts} = 3.06$, $t(323) = 6.81$, $p < .001$). Furthermore, average novelty was greater for the parts condition than the whole condition ($t(323) = 3.49$, $p < .001$). These results are displayed in Figure 2. A similar pattern was found for top creativity ($F(2, 323) = 9.69$, I < .001; top creativity was highest in the broken condition ($M_{broken} = 4.92$), followed by the parts condition ($M_{parts} = 4.64$), with the lowest in the whole condition ($M_{whole} = 4.2$). Curiously, fluency differed by condition ($F(2, 324) = 11.05$, $p < .001$), with participants able to generate more uses for whole wagons ($M_{whole} = 4.73$) followed by disassembled wagons ($M_{parts} = 4.55$) and the fewest for broken wagons ($M_{broken} = 3.57$). Planned contrasts revealed a significant difference between the number of uses generated in the broken condition compared to the other conditions ($t(324) = -4.65$, $p < .001$). I did not observe significant differences in average creativity, top creativity, or fluency for novel uses in the brick task (*p*s > .10). Likewise, I did not detect differences in convergent thinking as measured by the RAT ($F(2, 324) = 1.25$, $p = .29$). Moreover, I did not observe differences in preference for high novelty, low normativity t-shirts ($F(2, 324) = 1.85$, $p = .16$) or preference for low novelty, high normativity t-shirts ($F(2, 324) = .06$, $p = .94$).

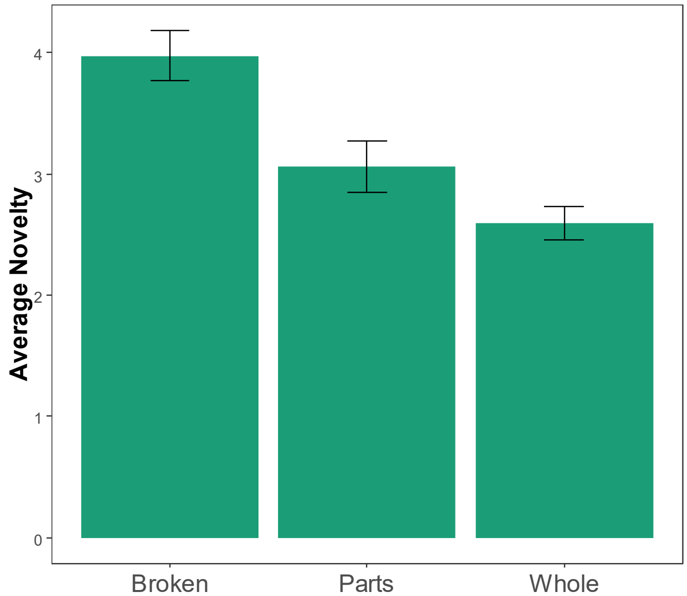


Figure 2. Bar plot of average novelty scores for Study 2. Depicts average novelty scores across conditions.

3.3.4 Discussion

Study 2 tested the possibility that participants are more creative with broken products because they mentally decompose the products into parts. I observed a similar effect on creativity by merely presenting participants with a disassembled version of the product, providing evidence in favor of my proposed mechanism. I failed to observe differences in convergent thinking and preference for original versus unoriginal products. Finally, I did not observe a downstream effect of increased creativity for the brick task. It is possible that, if the mechanism for my effect is indeed a chunk decomposition of the product into parts, I may only observe downstream differences in creativity for products that are compound (i.e., can be readily broken down into parts), in which case a brick may not be an appropriate stimulus. I conjecture that whether the focal product is primitive or a compound product which can be decomposed into meaningful chunks represents a boundary condition for observing the effect of brokenness on novel use generation. The remainder of the studies presented feature compound products as their stimuli.

3.4 Study 3

In Study 2, I investigated whether or not providing participants with a product that was disassembled would yield similar effects on novel use generation relative to providing participants with a product that was broken. However, because Study 2 only had three conditions—functional, broken, and disassembled—I was unable to infer with confidence the extent to which either factor was efficacious for improving creativity. Study 3 was conducted in order to tease apart the effects of each variable. In this study, I also created several measures intended to provide insight into variables that may play a mediating role between the manipulated variables and novel use generation. These include measures of functional fixedness chunking, chunk decomposition, and implicitly held constraints against product disassembly. I also sought to investigate whether the individual difference variable of analytic versus holistic thinking might interact with the variables being studied in this experiment. Analytic versus holistic thinking varies widely within and across cultures and has potential to impact whether participants view a product as a coherent whole or a series of parts (Nisbett et al, 2001; Choi et al, 2007; Monga and John, 2007). For example, analytic thinking is associated with viewing the world as composed of discrete objects which possess their own properties independent of their context, while holistic thinking is associated with viewing the world in terms of a collection of continuous substances or fields (Nisbett et al, 2001). At face value, it is possible that this individual difference variable could play a moderating role in the relationship between broken products and novel use generation. Additionally, in Study 3 I sought to create stimuli that were more detailed and realistic than the stimuli used in Study 2 in order to improve the ecological validity of the study. Furthermore, in Study 3 I sought to further investigate potential differences in the appropriateness of the uses that participants generate given the significance that creativity theorists place on the appropriateness dimension of creativity (Amabile, 1982).

3.4.1 Stimuli

To manipulate both factors in this study, I purchased a wagon and photographed it over several stages as I disassembled it, destroyed it, and reassembled it. The result was pictorial stimuli representing each factorial combination of the 2 (broken vs. functional) x 2 (whole vs. parts) study design. These stimuli are displayed in Figure 3.

Figure 3. Wagon images for Study 3. Stimuli for the functional/whole condition (top left), the functional/disassembled condition (top right), the broken/whole condition (bottom left), and the broken parts condition (bottom right).

3.4.2 Procedure

I collected data from 365 undergraduate students who participated in our study for extra course credit. I removed 8 responses from the analysis because they did not list interpretable uses during the unusual uses task. Accounting for the removal of these responses, this study yielded 357 responses (60% female). Participants were randomly assigned to view one of four images depicting either a functional whole wagon, a functional disassembled wagon, a broken whole wagon, or a broken disassembled wagon (Figure 3). At the beginning of the study, participants were simply instructed to imagine that they owned the wagon displayed in the image. They were then instructed to list as many uses for the wagon as they could think of.

Next, participants were asked to indicate their willingness to pay for the product. Afterwards, they responded to five Likert scale items which I developed to measure functional fixedness, constraint relaxation, chunking, and chunk decomposition. These variables were measured on a scale from 1 (Strongly disagree) to 7 (Strongly agree). Two items were included to measure functional fixedness: "I focused on the ways that wagons are typically used" and "I thought about uses for the wagon that were new and unconventional (reverse-scored)." The item developed to measure constraint relaxation read "I felt that it was okay to take the wagon apart." The item developed to measure chunking read, "I viewed the object as one coherent whole," while the measure for chunk decomposition read, "I viewed the wagon as several separate parts." Participants were also asked to respond to two items intended to measure their reductive versus holistic problem-solving habits: "When I attempt to solve a difficult problem, I tend to separate the problem into multiple sub-problems," and "When I attempt to solve a difficult problem, I tend to step back and view the problem from a broader perspective." After completing this battery of questions, participants were asked to respond to two manipulation checks. The first manipulation check asked whether the wagon they were shown earlier in the study was whole or separated into parts. The second manipulation check asked whether the wagon was functional/working properly or dysfunctional/broken. Afterwards, participants completed the 24-item analytic versus holistic thinking scale developed by Choi et al (2007). Example items from this scale include, "The whole, rather than its parts, should be considered in order to understand a phenomenon," "It is desirable to be in harmony, rather than in discord, with others of different opinions than one's own" and "Nothing is unrelated." Finally, participants were asked demographic questions.

3.4.3 Analysis

I identified 153 unique uses listed by participants in this study. Each of these uses was rated by two independent judges based on their novelty (1 = Not novel at all, 7 = Extremely novel) and appropriateness (1 = Not appropriate at all, 7 = Extremely appropriate). Discrepancies were resolved via discussion. These scores were averaged across response sets to calculate average novelty scores for each participant. Likewise, appropriateness scores were averaged across participants in order to calculate average appropriateness. I also measured the maximum value of each of these variables. Fluency was calculated by counting the number of items listed by each participant. The two items measuring functional fixedness were combined into an index measure ($\alpha = .57$) in order to quantify the extent to which participants fixated on conventional product uses as opposed to thinking of new and unconventional uses for the wagon. While I expected the constraint relaxation measure to be distinct from measures of chunking and chunk decomposition, each of the three measures were highly correlated, indicating that each item measured the same construct. After reverse-scoring the chunking variable I combined each of the three items into an index measure of chunk decomposition ($\alpha = .79$). For exploratory purposes, I created a measure of the average frequency of items listed in participants' response sets. This measure reflects the average frequency of the items generated by a given participant relative to the items generated by all of the other participants. Generally, high average frequency for a response set should correspond with lower novelty while low average frequency should correspond with greater novelty. Hypotheses 1 and 2 were tested using ANOVA.

3.4.4 Results

I examined the relationships between several of the variables measured in Study 3 by creating a correlation matrix which is depicted in Figure 4. Interestingly, average novelty and average appropriateness were strongly negatively correlated ($r = -.83$, $p < .001$). Conventional product uses tend to be quite appropriate, and the generation of novel uses entails a rejection of convention. It is interesting that creativity is conceptualized as the confluence of novelty and appropriateness (Sternberg and Lubert, 1991), given the negative relationship that I have observed here. However, this strong negative relationship can be understood by noting that creativity is often marked by a feeling of "effective surprise" upon noting something that is novel, yet contextually appropriate (Bruner, 1962). Creativity is surprising when it is encountered because the co-occurrence of novelty and appropriateness is actually quite rare. Creativity proper, compared to novelty, is not well-suited as an experimental metric. For this and other reasons, novelty is considered to be arguably the best metric of creativity within the context of experimental research; other metrics related to creativity can be unreliable or sensitive to spurious factors (e.g., frequency, Stokes, 2011). Average novelty, the primary variable of interest in this study, was negatively correlated with average frequency of uses listed ($r = -.80$, $p < .001$) which is unsurprising given that highly novel ideas should be observed infrequently throughout the dataset. Likewise, average novelty is positively correlated with top novelty ($r = .82$, $p < .001$) and fluency ($r = .20$, $p < .001$) both of which are implicit in the calculation of average novelty. Supporting my original hypothesis, chunk decomposition was positively correlated with average novelty ($r = .16$, $p = .002$) and top novelty ($r = .14$, $p = .007$). Chunk decomposition was negatively correlated with functional fixedness ($r = -.35$, $p < .001$), average frequency ($r = -.19$, $p < .001$), and average appropriateness ($r = -.11$, $p = .04$). Functional fixedness was positively correlated with average appropriateness ($r = .32$, $p < .001$) and negatively correlated with average novelty ($r = -.31$, $p < .001$), which is conceptually consistent with the phenomenon of functional fixedness as described in the literature review. Moreover, functional fixedness is negatively correlated with fluency ($r = -.25$, $p < .001$), which conflicts with accounts of functional fixedness as merely a special case of mental set. Under the mental set view, one would predict that functional fixedness would increase alongside the number of ideas generated, as each generated use further entrenches the mind into a deeper mental rut (Smith, 1995). The analytic vs. holistic variables were coded such that low values represent greater analytical thinking and high values indicate greater holistic thinking. This measure of analytic vs. holistic thinking was positively correlated with fluency ($r = .15$, $p = .004$), holistic problem-solving ($r = .24$, $p < .001$), and, counterintuitively, reductive problem-solving ($r = .14$, $p = .007$). Additionally, analytic vs. holistic thinking was negatively correlated with chunk decomposition ($r = -.13$, $p = .01$). In line with my thesis, reductive problem-solving was positively associated with average novelty ($r = .13$, $p = .01$), top novelty ($r = .12$, $p = .02$), fluency ($r = .11$, $p = .04$), and chunk decomposition ($r = .24$, $p < .001$), while being negatively associated with average frequency ($r = -.14$, $p = .006$). Surprisingly, holistic problem-solving was negatively associated with functional fixedness ($r = -.12$, $p = .03$) and reductive problem-solving ($r = .15$, $p = .005$). In principle, the holistic problem-solving measure and the reductive problem-solving measures were intended to be antagonistic and should not be positively correlated. In light of this discrepancy, it is possible that the holistic problem-solving measure captures to some degree the perspective shift that Duncker (1945) associated with a reduction in functional fixedness.

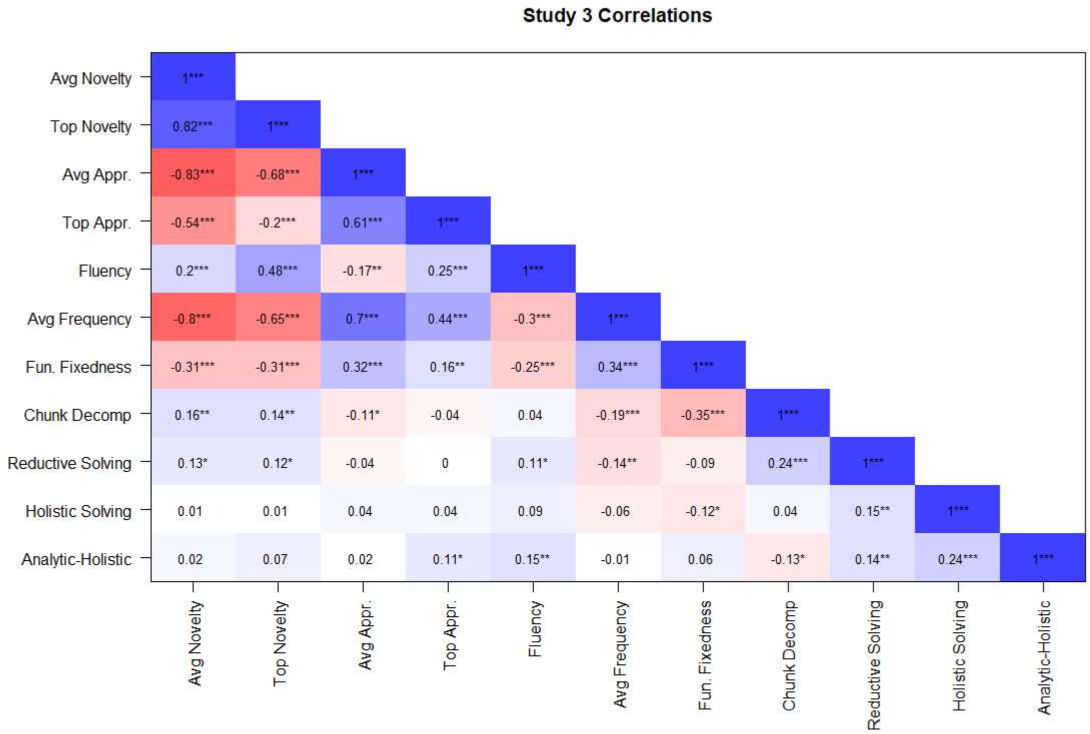


Figure 4. Correlation matrix of variables measured in Study 3.

*** denotes $p < .001$
** denotes $p < .01$
* denotes $p < .05$

The two-way ANOVA examining the effect of the broken vs. functional factor and the parts vs. whole factor on novel use generation yielded a statistically significant effect for the part vs. whole factor ($F(1, 353) = 9.67$, $p = .002$). Surprisingly, I did not observe an effect of brokenness on novel use generation ($F(1, 353) = .49$, $p = .45$; Hypothesis 1). This effect is shown in Figure 5. Examining the results of the manipulation check revealed that 54% of the participants that were shown a broken wagon failed to notice that the wagon was broken. This indicates that my manipulation of brokenness in this experiment was not effective, and limits the strength of the conclusions that can be drawn regarding the broken product manipulation.

Willingness to pay did not differ by condition (*p*s > .05). This serves as further evidence that the manipulation of brokenness was not effective, as one ought to expect consumers to be willing to spend more money on a functional wagon than a broken one. A two-way ANOVA indicated that participants reported greater functional fixedness when the wagon was whole as opposed to disassembled ($F(1, 353) = 6.70$, $p = .01$). Additionally, participants exhibited greater chunk decomposition when the product was broken ($F(1, 353) = 4.00$, $p < .05$) and when the product was disassembled ($F(1, 353) = 20.00$, $p < .001$), but the interaction was not significant ($F(1, 353) = .03$, $p = .85$). Uses were judged to be more appropriate when the wagon was whole ($F(1, 353) = 7.90$, $p = .005$). Average frequency did not differ by condition (*p*s > .05) and neither did fluency (*p*s > .05).

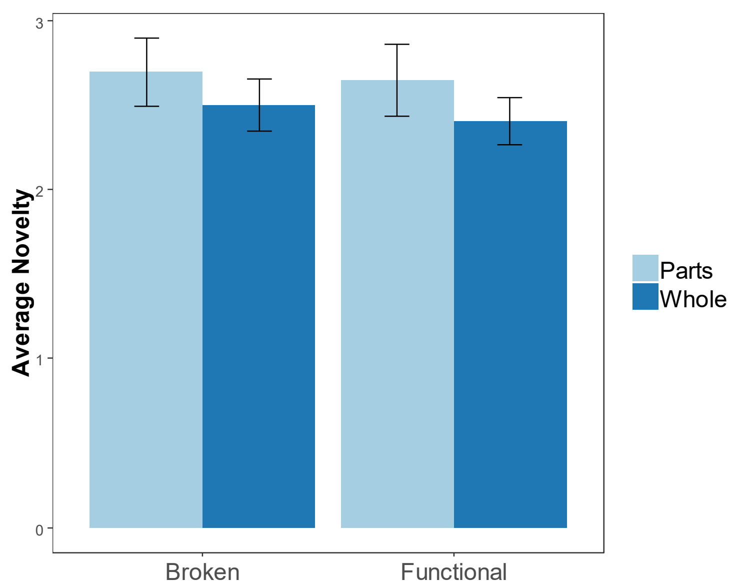


Figure 5. Bar plot of the average novelty of uses by condition in Study 3.

3.4.5 Discussion

The results of Study 3 provided additional support for the notion that chunk decomposition plays a mediating role in the relationship between broken products and novel use generation. However, because the brokenness manipulation was not effective, the main effect of brokenness on novel use generation was not observed, which weakened the strength of conclusions that can be drawn from this study. That said, in Study 3 I developed measures for functional fixedness and chunk decomposition which bore logically consistent relationships to the other variables being studied. These variables were explored further in Studies 4 and 5. Additionally, in this study I observed a strong negative relationship between novelty and appropriateness, which indicates that functional fixedness has heuristic value in that it orients consumers towards contextually appropriate and conventional product uses. Furthermore, I investigated the trait of analytic versus holistic thinking and found that, while it bore a relationship to the chunk decomposition variable, it did not exhibit a significant relationship on novel use generation. As such, this variable was not studied further.

3.5 Study 4

According to Stokes (2007), problems which yield novel ideas have the characteristic of precluding search among reliable, expected responses while promoting search among risky, surprising ones. This account may explain the effectiveness of the broken product manipulation on creativity; when the product is broken, search among familiar uses for the product is precluded, while search among unfamiliar uses is facilitated. Study 4 is designed to test the veracity of this account by introducing an alternative manipulation which applies a paired constraint following the form described by Stokes (2007). This manipulation is distinct from product functionality but nevertheless precludes search among familiar uses while facilitating search among unfamiliar uses. In addition to manipulating the functionality of the product, I will manipulate attributes of the problem environment in order to test Hypotheses 5a and 5b. Additionally, Study 4 examines the effect of product functionality on novel use generation using a different product—a lawn mower. If this hypothesis is supported, this would represent evidence towards the validity of the paired constraints model. Additionally, the results of Study 4 will provide information about the causal pathway between product functionality and novel use generation.

3.5.1 Procedure

The study followed a 2 (product type: broken versus functional) X 2 (environment type: lawn versus desert) factorial design. Participants were asked to imagine the following scenario: "Imagine that you have just moved to a new house. While unpacking, you find a lawn mower that you brought from your old house. You notice that this lawn mower is functional and can be started with ease [broken and cannot be started at all]. After unpacking your lawn mower, you examine your property and see [realize] that the house you have moved to is in a lush environment and has a lawn [a desert environment and does not have a lawn]." Afterwards, they were asked to list as many uses for the lawn mower as they could think of. Next, participants responded to the measures of functional fixedness, chunk decomposition, reductive problem solving, and holistic problem solving described in Study 3 as well as manipulation checks for each predictor variable. Additionally, I asked participants to report their familiarity with lawn mowers on a scale from 1 (Very unfamiliar) to 7 (Very familiar). I also included three Likert scale items intended to measure participants' general attitudes towards taking products apart.

These items were “I feel comfortable taking things apart,” “I prefer not to take things apart” (reverse-scored), and “It is okay to take things apart, even if there is no particular reason to do so.” Finally, participants were asked demographic questions.

3.5.2 Analysis

For this study, I aimed to collect data from approximately 400 MTurkers, and ended up collecting 410 responses. I deleted 23 responses associated with repeat responses from the same IP address. Additionally, I removed 9 responses from analysis due to failure to list interpretable uses during the unusual uses task. After accounting for the removal of these observations, the data consisted of 378 responses (50% male). I read each response to the UUT prompt and identified 125 unique uses along with 23 categories to which these uses could be assigned. Instead of consulting two expert judges, I consulted 12 members from a population of peers to obtain novelty ratings for each use, following protocol from previous research (Dahl et al, 1999; Mehta et al, 2012; Mehta et al, 2017). Novelty ratings from each judge were averaged together, resulting in a single novelty score for each use. Agreement between judges was quite high (α = .98). The three items introduced in this study as measures of general attitudes towards disassembly were averaged together to form an index measure (α = .75). Flexibility was calculated as the number of unique categories represented in each participants response set. As in Study 4, the measure of functional fixedness was calculated using a combined measure of participants’ focus on conventional product uses and a reverse-scored measure of thinking about novel and unconventional uses for the product. This measure was used as a proxy measure for Stokes’ (2007) constraint pair concept. The chunk decomposition measure was described in Study 3. This measure was also reverse-scored into a variable representing chunking, conceptualized as the opposite of chunk decomposition. I elected against reverse scoring functional fixedness, as there is currently no conceptual label for the opposite of functional fixedness.

I tested a moderated serial mediation model using Hayes' PROCESS model 92 in R (Hayes, 2013). I specified product functionality as the independent variable, environment type as the moderator, chunking as the first mediator, functional fixedness as the second mediator, and novelty as the dependent variable. Bootstrap 95% confidence intervals were calculated using 10,000 bootstraps. To facilitate interpretation within this model, I coded the product functionality variable such that 1 = function and 0 = broken. Likewise, the environment variable was coded such that 1 = lawn and 0 = desert. Chunk decomposition was reverse scored and can conveniently be interpreted as chunking.

3.5.3 Results

The results of the two-way ANOVAs for the primary variables of interest in this study are displayed in Figure 6. T-tests indicated a significant main effect of product functionality on average novelty (M_{broken} = 2.98, $M_{functional}$ = 2.73, $t(372.65) = 3.79$, $p < .001$) and a significant main effect of environment on average novelty (M_{desert} = 3.09, M_{lawn} = 2.60, $t(372.31) = 7.70$, $p < .001$). The interaction of these terms was not significant ($F(1, 374) = 2.28$, $p = .13$). Additional two-way ANOVAs revealed a significant main effect of product functionality on chunking ($F(1, 374) = 71.30$, $p < .001$), a main effect of environment on chunking ($F(1, 374) = 35.73$, $p < .001$), as well as an interaction effect ($F(1, 374) = 10.33$, $p < .001$). Additionally, there was a main effect of product functionality on flexibility ($F(1, 374) = 11.36$, $p < .001$), a main effect of task environment on flexibility ($F(1, 374) = 5.74$, $p = .02$), as well as an interaction effect ($F(1, 374)$

= 5.64, $p = .02$). There was a main effect of product functionality on chunking ($F(1, 374) = 69.76$, $p < .001$), a main effect of task environment on chunking ($F(1, 374) = 37.45$, $p < .001$), and an interaction effect of these terms ($F(1, 374) = 10.33$, $p = .001$). For ease of comparison with previous studies, I note that the chunking variable is simply a reverse-scored version of the chunk decomposition variable, and the results for a two-way ANOVA on chunk decomposition yield equivalent, mirrored results. I also observed a main effect of product functionality on functional fixedness ($F(1, 374) = 6.22$, $p = .01$), a main effect of task environment on functional fixedness ($F(1, 374) = 42.71$, $p < .001$) and a marginal interaction effect ($F(1, 374) = 3.78$, $p = .05$). Likewise, I observed a significant main effect of product functionality on average frequency ($F(1, 374) = 23.51$, $p < .001$), a main effect of task environment on average frequency ($F(1, 374) = 91.63$, $p < .001$) and an interaction effect of these terms ($F(1, 374) = 12.25$, $p < .001$). In order to explore whether differences in novel use generation were caused by participants generating uses that were less and less novel, as would be expected under a mental rut account of functional fixedness, I investigated the effects of each predictor variable on the novelty score for the first item generated by each participant. The results indicated that participants generate more novel uses from the very beginning; the main effect of product functionality on the novelty of the first use listed was significant ($F(1, 374) = 18.82$, $p < .001$), as well as the main effect of task environment ($F(1, 374) = 103.23$, $p < .001$) and the interaction of both terms ($F(1, 374) = 11.78$, $p < .001$). Fluency did not differ significantly across groups (ps > .10).

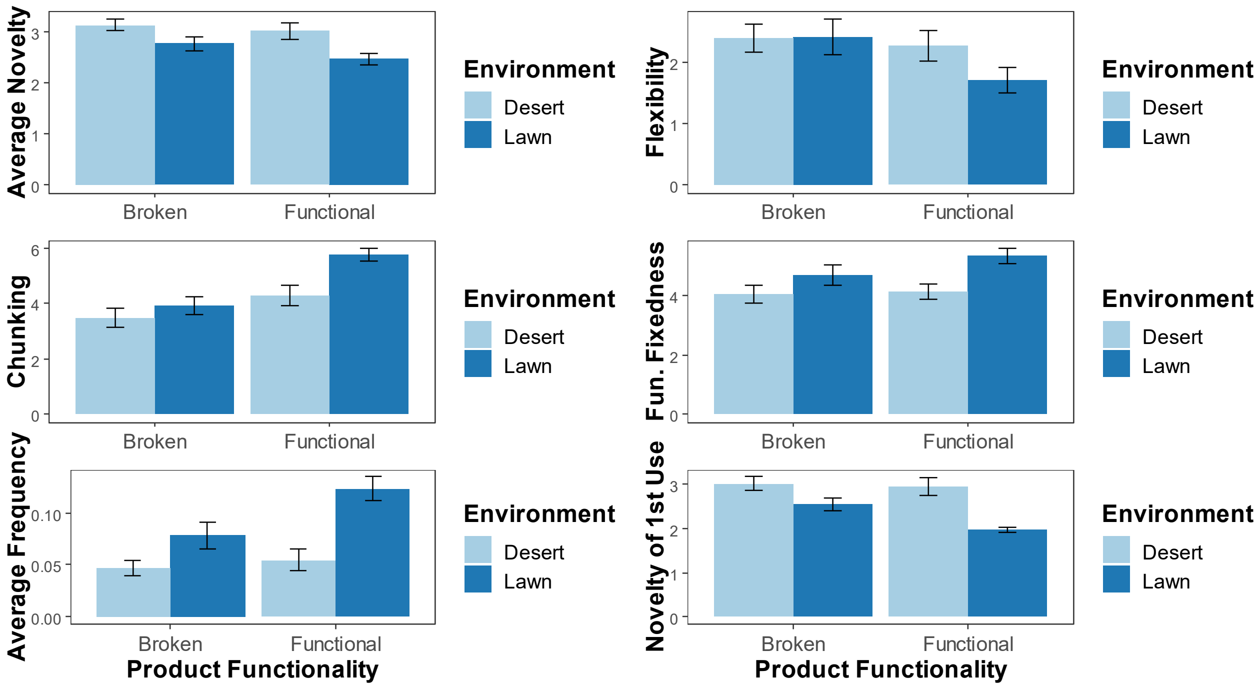


Figure 6. Bar graph matrix of Study 4 results. Displays the effects of product functionality and task environment on the average novelty of uses generated (top left), flexibility (top right), chunking (middle left), functional fixedness (middle right), average frequency of uses listed (bottom left), and novelty score of the first item listed (bottom right).

The relationships observed in this study are displayed Figure 7. Average novelty was positively correlated with chunk decomposition (r = .27, p < .001), flexibility (r = .42, p < .001), and fluency (r = .28, p < .001), but negatively correlated with chunking (r = -.27, p < .001), functional fixedness (r = -.45, p < .001), and average frequency (r = -.79, p < .001). Additionally, chunk decomposition was positively correlated with top novelty (r = .28, p < .001), fluency (r = .21, p < .001), and flexibility (r = .31, p < .001), but negatively correlated with average frequency (r = -.33, p < .001) and functional fixedness (r = -.49, p < .001). Attitude towards disassembly exhibited relationships with average novelty (r = .11, p = .03), fluency (r = .12, p =

.02), average frequency (*r* = -.13, *p* = .01), functional fixedness (*r* = -.20, *p* < .001), chunk decomposition (*r* = .32, *p* < .001), familiarity (*r* = .16, *p* = .001), reductive problem solving (*r* = .34, *p* < .001), and holistic problem solving (*r* = .19, *p* < .001). Additionally, functional fixedness was negatively associated with reductive problem-solving (*r* = -.14, *p* = .005). Familiarity was positively associated with both holistic problem-solving (r = .23, p < .001) and disassembly (r = .16, p = .001).

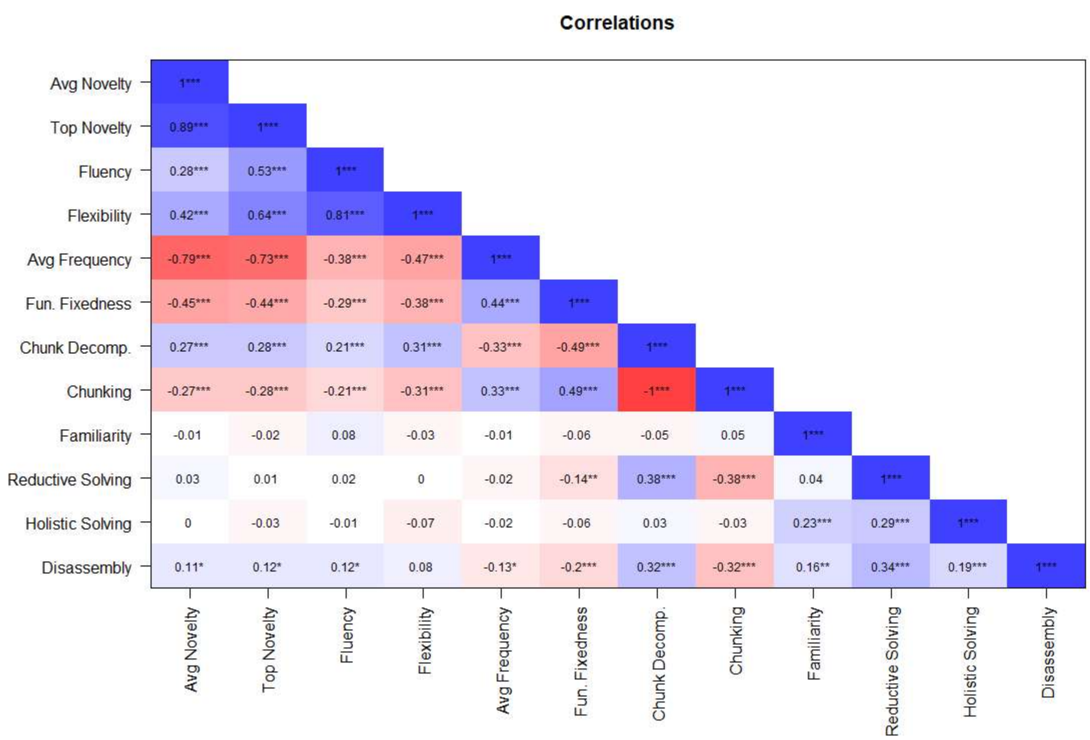
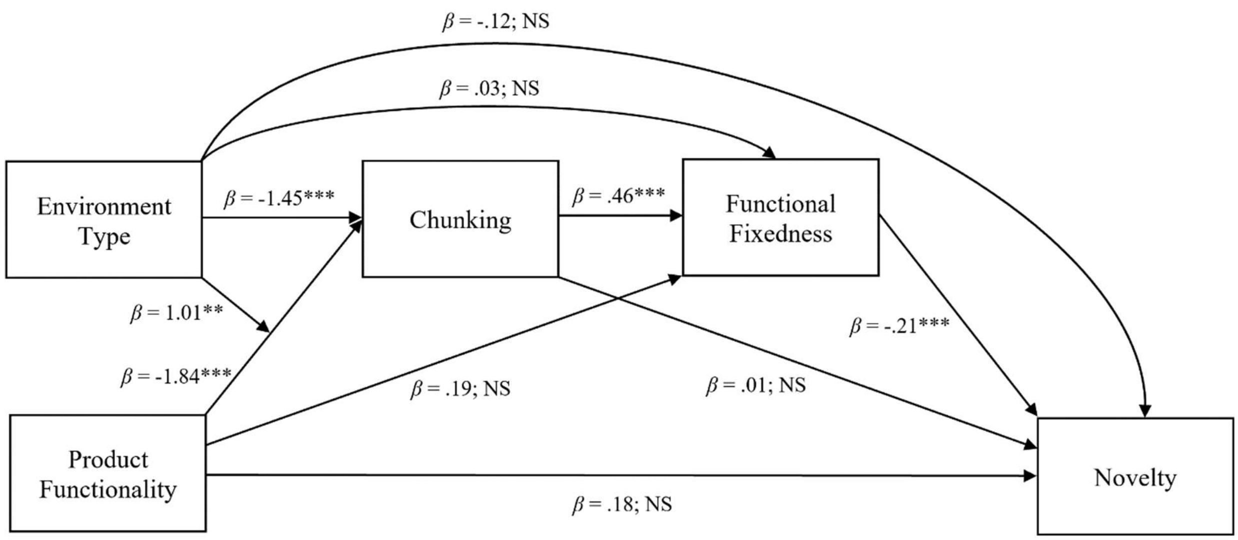


Figure 7. Correlation plot of variables measured in Study 4.

*** denotes *p* < .001
** denotes *p* < .01
* denotes *p* < .05

The overall fit for the moderated mediation model was statistically significant ($F(7, 374) = 20.94$, MSE = 0.33, $p < .001$) and is displayed in Figure 8. The direct effect of product functionality on novelty was not significant ($\beta = .18$, SE = .10, $p = .08$). There was a significant direct effect of product functionality on chunking ($\beta = -1.84$, SE = .23, $p < .001$). However, the direct effect of product functionality on functional fixedness was not significant ($\beta = .19$, SE = .23, $p = .40$). Since there was a significant effect of chunking on functional fixedness ($\beta = .46$, SE = .07, $p < .001$), a significant effect of functional fixedness on novelty ($\beta = -.21$, SE = .03, $p < .001$), and no direct effect of chunking on novelty ($\beta = .01$, SE = .04, $p = .79$), the absence of a direct effect of product functionality on functional fixedness indicates that product functionality impacts functional fixedness only indirectly via the chunking variable. A similar causal pathway can be seen emanating from the environment type variable. Environment type yielded a significant direct effect on chunking ($\beta = -1.45$, SE = .22, $p < .001$), but did not significantly affect functional fixedness ($\beta = .03$, SE = .50, $p = .95$), or novelty ($\beta = -.12$, SE = .26, $p = .65$). The interaction effect of product functionality and environment type on chunking was significant ($\beta = 1.01$, SE = .32, $p = .001$). The conditional indirect effect of product functionality (lawn condition) was significant ($\beta = .18$, SE = .04 [.10, .27]). The conditional indirect effect of product functionality (desert condition) was also significant ($\beta = .03$, SE = .02 [.01, .07]). These were subtracted from one another to calculate an index of moderated mediation, which was significant ($\beta = -.15$, SE= .05 [-.25, -.06]).



Model Fit: R^2 = .28, F(7, 374) = 20.94, MSE = 0.33, p < .001
Direct Effect: β = .18, SE = .10, p = .08
Conditional Direct Effect (Lawn Condition): β = .18, SE = .10, p = .08
Conditional Direct Effect (Desert Condition): β = .12, SE = .09, p = .16
Conditional Indirect Effect (Lawn Condition): β = .18, SE = .04 [.10, .27]
Conditional Indirect Effect (Desert Condition): β = .03, SE = .02 [.01, .07]
Index of Moderated Mediation: β = -.15, SE= .05 [-.25, -.06]

(R) Denotes reverse coding.
* p < .05
** p < .01
*** p < .001

Figure 8. Moderated mediation model for Study 4. Displays the results of a moderated mediation model produced using Hayes PROCESS model 92 in R (Hayes, 2013).

3.5.4 Discussion

Taken together, the large main effects of each predictor variable on chunk decomposition, the reversed sign on the term of their interaction, and the reversed sign on the index of moderated mediation indicate that product functionality and environment type are interacting additively rather than multiplicatively with one another. Including environment type as a moderator in the serial mediation model reduces its efficacy because both predictor variables are moving through the same causal pathway. The model supports the account that participants generated less novel uses for the functional lawn mower because they chunked the product into one coherent whole, leading to functional fixedness and an inability to generate variability around uses for the chunked product. Alternatively, it can be stated that participants generated more novel uses for the broken lawn mower because they did not chunk the lawn mower, preventing functional fixedness from occurring and allowing them to freely generate variability around uses for the product. A similar effect occurred for the environment type manipulation. Participants that generated ideas for the lawn mower in a lush environment containing a lawn were more likely to chunk the lawnmower into one coherent whole, leading to functional fixedness and an inability to generate variability around its potential uses. In contrast, participants that were asked to generate ideas for the lawn mower in a desert environment that did not contain a lawn were less apt to chunk the lawn mower and consequently less apt to fixate on a narrow range of uses for it. Both the functional lawn mower and the lawn environment promoted search among conventional uses for lawn mowers while precluding search among unconventional uses for lawn mowers. Conversely, both the broken lawn mower and the desert environment precluded search among conventional uses while promoting search among unconventional uses. This finding supports the dual constraint model (Stokes, 2007). In addition, the results of this study indicate that the dual constraint model is preceded by chunking effects; whether a novelty conducive constraint or a novelty impeding constraint is applied depends critically upon how contextual information is chunked together in short term memory. The order of the mediating variables in this model can be understood in terms of the chronological order with which each variable could plausibly occur. Chunking is a rapid and automatic process, and ought to precede the comparatively slower processes of deliberating over uses for a product.

To the best of my knowledge, the observation that chunking precedes functional fixedness represents a novel theoretical contribution. This finding indicates that disrupting the chunking process that occurs when a problem solver confronts a task environment may disrupt functional fixedness from occurring in the first place, allowing problem solvers to produce novel ideas unimpeded by the conventional uses that would be cued under normal circumstances. This interpretation of functional fixedness is also consistent with theories from the insight problem solving literature; in this literature, researchers have observed that functional fixedness can be resolved by a restructuring of the problem representation (Duncker, 1945), decomposing chunks into parts (Knoblich et al, 1999; McCaffrey, 2012), and incubation (Poincaré, 1908/1952, Finke et al, 1992). Each of these remedies for functional fixedness implicate the dissolution of chunks formed during the initial problem representation. It is possible that functional fixedness, and perhaps fixation effects more generally, are simply epiphenomena of chunking. One can think of, for example, Duncker's (1945) empty box versus full box manipulation as two different chunks, the latter promoting search among uses associated with containment while precluding search among uses not associated with containment. This finding is also interesting in light of the fact that chunking preceded functional fixedness for both predictor variables. Simply noting that the lawn mower was located in a property which contained a lawn led participants to view the lawn mower as a coherent whole object, which fixated their minds on conventional uses to the detriment of their ability to generate novel ones. Furthermore, the results of this study provide evidence indicating that functional fixedness can be manipulated through changes in either the product itself or the task environment within which the product is situated. Finally, the results of Study 4 indicate that the effect of broken products on novel use generation can also be interpreted as a negative effect of functional products on novel use generation, as functional products lead to chunking and functional fixedness, resulting in uses that are less novel.

Chapter 4: Downstream Effects

4.1 Study 5

Studies 1-4 demonstrated that consumers generate more novel uses for products that are broken. Furthermore, these studies provided evidence that this effect occurs because consumers view broken products in terms of their parts. Or, stated alternatively, consumers generate less novel uses for functional products because they view them as coherent wholes. Viewing products as wholes contributes to functional fixedness, which inhibits participants from deviating from conventional product uses. The purpose of Study 5 was to examine whether the psychological effects used to account for the effects observed in Studies 1-4 are localized to interactions with that specific product or yield downstream consequences for a different product encountered subsequently. Study 5 also addresses an alternative explanation for the findings discussed in Chapter 1. One explanation is that interacting with broken products activates a general problem-solving mindset, and this leads to greater creativity in the UUT (Weatherford et al, 2021). I view this alternative account as flawed, primarily because a problem-solving mindset ought to orient problem solvers towards repairing the broken product as opposed to generating novel uses for it. A priori, I see no reason why a consumer with an activated problem-solving mindset would not exhibit functional fixedness.

However, representational change theory does offer a mechanism, constraint relaxation, which in theory would allow for a transfer effect between an UUT with a broken product and a subsequent UUT with a different product (Knoblich et al, 1999). According to representational change theory, problem solvers apply implicit constraints to problems. It may be the case that participants performing the UUT apply implicit constraints which specify what they can and cannot do in the context of the task. One such constraint may be a rule specifying that the object in the UUT cannot be taken apart. One possibility is that the broken product manipulation is efficacious in part because it nullifies this implicit constraint. Given that constraints which are relaxed in one task are relaxed for subsequently encountered tasks (Knoblich et al, 1999), it follows that participants who perform the UUT for a broken product will generate more creative uses in a subsequent UUT for a product which is not broken (See H_4). This prediction is also consistent with research on analogical transfer in problem solving contexts, because information learned in one problem is likely to be applied to subsequent problems which are judged to be similar by the problem solver. If participants learn that they are allowed to take products apart during the UUT, they may relax this constraint in a subsequent UUT. Note that this prediction only holds if the subsequently encountered product can conceivably be broken into parts. Consistent with the theme of searching for downstream consequences, I also sought to explore whether participants would exhibit increased convergent creativity after performing the UUT with a broken product (Mednick, 1962).

4.1.1 Procedure

I collected 342 responses from undergraduate participants volunteering to take the study for extra course credit. However, 23 responses were duplicate responses and 12 responses did not list any interpretable uses for the UUT. These responses were removed from analysis, leaving a total of 307 responses (55% female). Participants were randomly assigned to the broken condition or the functional condition. Participants were given the following instructions: "Imagine that you are pulling a red wagon. You look at the wagon and notice that the wheels are turning smoothly [not turning at all]." They were then instructed to list as many uses for the wagon as they could think of. Afterwards, they were asked to list as many uses as they could think of for a silver pair of scissors. Participants next answered a series of Likert scale questions designed to measure a) implicit constraints against taking either product apart and b) information transfer from the wagon UUT to the scissors UUT. These items read “When I was thinking about uses for the wagon, in my mind I felt it was okay to take the wagon apart,” “When I was thinking about uses for the scissors, in my mind I felt it was okay to take the scissors apart,” “Listing uses for the scissors was similar to listing uses for the wagon,” “When I listed uses for the scissors, I drew upon what I had learned from listing uses for the wagon,” and “Listing uses for the wagon had an impact on how I listed uses for the scissors.” Next, participants were given a manipulation check and provided with 10 items from the remote associates test, which measures convergent thinking (Mednick, 1962; Bowden and Jung-Beeman, 2003). The items chosen were calibrated such that 60%-80% of participants reached solution within 30 seconds (Bowden and Jung-Beeman, 2003). Participants were given 30 seconds per question to enter a word related to a set of three other words. For example, one item provided participants with the words “fish,” “mine,” and “rush.” The correct response to this question is “gold.” After completing the 10 RAT items, participants were asked demographic questions and the study concluded.

4.1.2 Analysis

I identified 130 unique uses listed by participants in response to the wagon UUT and 169 unique uses listed in response to the scissors UUT. Two independent judges rated each use based on how novel they were on a scale from 1 (Not novel at all) to 7 (Extremely novel) as well as how appropriate they were on a scale from 1(Not appropriate at all) to 7(Extremely appropriate) with discrepancies resolved via discussion. Novelty scores for each use listed by each participant were averaged across response sets, resulting in metrics of the average novelty of each participants' response to each UUT. The same method was used to calculate scores for appropriateness. My primary hypothesis for this study was tested using a t-test specifying product functionality (broken vs. functional) as the predictor variable and average novelty (scissors) as the response variable. I averaged the three items designed to measure transfer together to form an index measure ($\alpha = .78$). Additionally, I tested a simple mediation model to examine whether this index measure of transfer would mediate the predicted effect of performing the UUT with a broken vs. functional wagon on the average novelty score for the scissors UUT. Each correct response to the RAT items was assigned a 1. Final RAT scores were calculated by summing scores for each RAT item, resulting in a score ranging between 0 and 10 (inclusive), with higher scores indicating greater convergent thinking.

4.1.3 Results

The analysis revealed a replication of the main effect of product functionality (wagon) on average novelty ($M_{broken} = 2.67$, $M_{functional} = 1.83$, $t(305) = 7.62$, $p < .001$) and top novelty ($M_{broken} = 3.66$, $M_{functional} = 2.97$, $t(305) = 3.69$, $p < .001$). I also observed differences between condition on the average appropriateness ($M_{broken} = 5.78$, $M_{functional} = 6.13$, $t(305) = -3.02$, p < .001) and top appropriateness ($M_{broken} = 6.59$, $M_{functional} = 6.93$, $t(305) = -4.60$, p < .001) of uses listed for the wagon. I did not observe the hypothesized transfer effect of product functionality (wagon) on either the average novelty ($M_{broken} = 1.81$, $M_{functional} = 1.83$, $t(305) = -.24$, $p = .81$) or top novelty ($M_{broken} = 3.06$, $M_{functional} = 3.22$, $t(305) = -.79$, $p = .43$) of uses generated in the scissors task. Likewise, neither average appropriateness nor top appropriateness for the scissors task differed between conditions (ps > .10). Additionally, fluency did not differ between conditions for either the wagon task or the scissors task (ps > .10). Furthermore, no between-group differences were found for performance on the RAT ($p > .10$). Participants did not differ across conditions in the extent to which the wagon UUT impacted their performance on the scissors UUT ($M_{broken} = 3.26$, $M_{functional} = 3.12$, $t(305) = .91$, $p = .36$). The low average for this measure across all participants (M = 3.19) indicated that on average participants tended to disagree with the statements used in the transfer self-report measures. Furthermore, participants reported greater relaxation for a constraint against taking the wagon apart when it was broken than when it was functional ($M_{broken} = 3.75$, $M_{functional} = 2.70$, $t(305) = 5.18$, $p < .001$), but no differences between condition were found in regards to relaxation of constraints against taking the scissors apart ($M_{broken} = 3.16$, $M_{functional} = 2.88$, $t(305) = 1.37$, $p < .001$).

4.1.4 Discussion

This study provided additional evidence for the effect of broken products on novel use generation. However, the results did not support the hypothesis that interacting with broken products would have downstream consequences on novel use generation for other products. It appears that the psychological effects at play in this context are localized to the product at hand. Additionally, the results of this study did not support a mindset account explaining effects of broken products on novel use generation in terms of changes to the mind of the consumer. A parsimonious account of the experimental findings presented in this dissertation is that the effect of broken products on novel use generation is caused by contextual variables localized to the task environment. If within-person variables were responsible for the aforementioned effect, I would have expected to observe differences in within-person measures of novelty after these within person variables were activated in the wagon UUT. I did not observe downstream effects on creativity; however, this does not rule out the possibility that interacting with broken products yields meaningful effects on disposal behaviour.

4.2 Study 6

Study 6 was designed to explore the potential downstream consequences of consumers engaging with broken products in a creative way. Specifically, I was interested in finding whether performing the novel uses task with a broken product had any effect on the manner in which consumers might dispose of the product. I expected that consumers that conducted the novel uses task with a broken wagon would be less likely to indicate that they would throw it in the trash, and perhaps more likely to indicate that they would recycle, reuse, repurpose, or sell the product.

4.2.1 Procedure

I collected data from 425 Mturkers (55% male) who participated in the study in exchange for monetary compensation. The study followed a 2 (product type: broken vs functional) X 2 (usage listing vs. control) between-subjects factorial design. Participants were asked to imagine a broken [functional] wagon and were presented with an image of a broken [functional] wagon. In the usage listing condition, participants were asked to list as many uses for the wagon as they could think of. In the control condition, participants were not given any task. Participants were then asked a battery of questions regarding how likely they would be to trash, reuse, recycle, repurpose, or sell the wagon (anchored at 1 = Extremely unlikely and 7 = Extremely likely). Participants were also asked how likely they would be to break the wagon into parts, as a check for the mediating variable. As a manipulation check, participants were asked whether the wagon they were presented with was broken or functional. Finally, participants answered demographic questions and were given instructions on how to receive their payment.

4.2.2 Analysis

Because the primary purpose for this study was to examine the potential downstream consequences of consumers engaging creatively with broken versus functional products, the creativity of uses generated by participants was not analyzed. Instead, I examined the effects of my manipulation on several hypothetical disposal measures using two-way ANOVA.

4.2.3 Results

I found a main effect on likelihood of throwing the wagon in the trash when it was broken rather than functional ($M_{broken} = 4.9$, $M_{functional} = 2.48$, $F(1) = 189.90$, $p < .001$), no main effect for the usage listing intervention ($M_{listing} = 3.71$, $M_{control} = 3.65$, $F(1) = .26$, $p = .61$), and no interaction between the product type and the usage listing intervention ($F(1) = 0.75$, $p = .39$). I did, however, observe a significant main effect for the listing intervention on the self-reported likelihood of recycling the wagon ($M_{listing} = 5.04$, $M_{control} = 4.5$, $F(1) = 11.43$, $p < .001$), with no main effect for condition ($M_{broken} = 4.63$, $M_{functional} = 4.89$, $F(1) = 2.58$, $p = .11$) and no interaction ($F(1) = .69$, $p = .41$). This result is displayed in Figure 9. There was a main effect of product type on likelihood of reusing the wagon ($M_{broken} = 4.14$, $M_{functional} = 6.08$, $F(1) = 156.20$, $p < .001$) a marginal main effect of the usage listing intervention ($M_{listing} = 5.2$, $M_{control} = 5.05$, $F(1) = 2.92$, $p = .09$), and no interaction ($F(1) = 0.53$, $p = .47$). There was a main effect of product type on likelihood of repurposing the wagon ($M_{broken} = 4.68$, $M_{functional} = 5.34$, $F(1) = 16.78$, $p < .001$), no main effect for the usage listing intervention ($M_{listing} = 5.08$, $M_{control} = 4.94$,

$F(1) = 1.18$, $p = .28$), and no interaction ($F(1) = 0.13$, $p = .72$). There was a main effect of product type on likelihood of selling the wagon ($M_{broken} = 2.79$, $M_{functional} = 4.48$, $F(1) = 88.49$, $p < .001$), no main effect for the usage listing condition ($M_{listing} = 3.5$, $M_{control} = 3.78$, $F(1) = 1.06$, $p = .30$), and no interaction effect ($F(1) = 0.47$, $p = .49$).

Importantly, there was a significant main effect of product type on participants propensity to view the wagon as being composed of a series of parts ($M_{broken} = 3.92$, $M_{functional} = 2.64$, $F(1) = 47.27$, $p < .001$), no main effect of the usage listing intervention ($M_{listing} = 3.3$, $M_{control} = 3.25$, $F(1) = .01$, $p = .90$), and a significant interaction effect ($F(1) = 4.69$, $p = .03$).

4.2.4 Discussion

The results of Study 6 indicate a positive relationship between broken products, the usage listing task, and the propensity to recycle. I found that those participants which were shown a broken product and asked to list uses for the product indicated a higher likelihood of recycling it. Moreover, I observed a marked difference in participants propensity to view the wagon as a series of component parts. When I consider that recycling a wagon necessarily involves decomposing the wagon into component parts, these results support my proposed process model, providing additional evidence that participants are mentally breaking the broken wagon, but not the functional wagon, into parts.

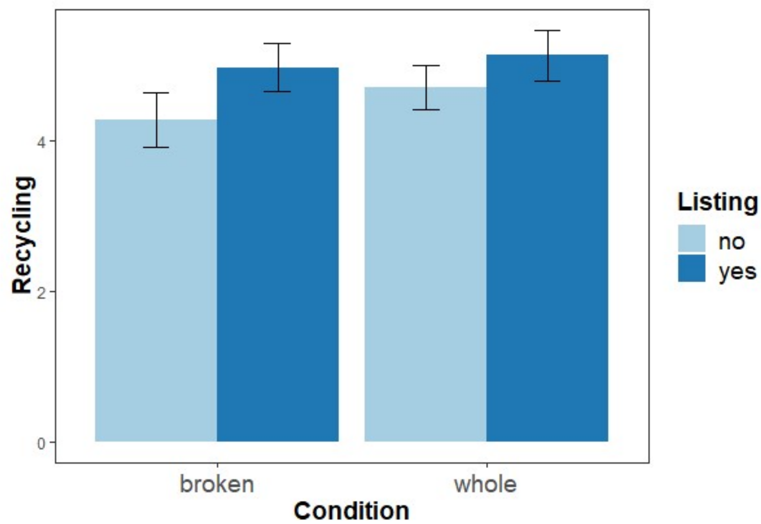


Figure 9. Bar plot of recycling likelihood reported in Study 6. Depicts differences between conditions for self-reported likelihood of recycling a broken wagon. Error bars display 95% confidence intervals.

4.3 Study 7

The results of Study 6 provided evidence that performing the UUT for a broken wagon (but not a functional wagon) increases participants' self-reported likelihood of recycling it. I reasoned that this may be due to participants mentally decomposing the broken wagon into parts during the UUT. Breaking products into parts is a necessary step for recycling compound consumer products; recycling by definition requires the reduction of products to their raw materials. However, the variety of shapes, sizes, and composition of consumer products makes the automation of this process intractable. To address this problem, recycling services outsource the decomposition of recyclable products to consumers. As shown in previous research on recycling behaviour, interventions which make recycling more fluent for the consumer tend to yield higher rates of recycling (White et al, 2011). If the process model I have developed to account for the effect of broken products on novel use generation is correct, consumers mentally decompose products that are broken during the UUT. This mental decomposition increases the fluency of the process of recycling the product. The purpose of Study 7 was designed to test whether the unusual uses manipulation increases recycling behaviour in a laboratory environment.

4.3.1 Stimuli

In order to test whether the effect which I have been studying was generalizable to products other than wagons, I selected a handheld electric fan to serve as the experimental stimulus. Originally, each fan consisted of a plastic body with two Styrofoam fan blades, two batteries, and an aluminum carabiner. Half of the fans were left in an unmodified and fully functional state such that the flip of a switch on the body of the fan would set the fan blades in motion, creating a light breeze. The other half of the fans were manually broken by cutting off one Styrofoam blade and removing one battery, rendering the fan dysfunctional. Inside the battery housing I placed a hidden label containing a unique identification number which could be used to match each disposed fan with participants' study responses and assigned condition.

4.3.2 Procedure

This experiment took place in a university laboratory consisting of an entry room and four small breakout rooms. I recruited 239 undergraduate students (55% female) to participate in this study for extra course credit. I originally planned to recruit 400 participants, but the data collection was abruptly halted by a full-scale university shutdown in response to the outbreak of covid-19. Upon arrival to the lab, each participant was directed to a breakout room and asked to complete a series of unrelated studies on a laptop computer. My study was positioned at the end of this series of studies. The study followed a 2 (product condition: broken vs. functional) X 2 (intervention: uses listing vs. control) factorial design. The laptops in each room contained a different version of the study, and participants were randomly assigned to one of the four rooms at the beginning of each session. Next to each laptop I placed a fan which was covered by a piece of paper. I also placed a snippet of paper at each desk which contained a unique identification number matching that of the label hidden inside the fan. At the beginning of the study, participants were instructed to type this number into the computer. Next, participants were asked to remove the sheet of paper and take a moment to inspect and interact with the fan underneath it. Participants were then presented with a series of exploratory measures regarding participants' evaluation of the product. These measures were willingness to pay (measured in Canadian dollars), attitude towards the product (measured by a 3-item index of valence, liking, and favorability of the product), likelihood of recommending the product to a friend, and a rating of the condition of the product. The rating of the condition of the product was included as a manipulation check. Next, participants in the uses listing condition were instructed to list as many uses for the fan as they could think of. Participants in the control condition were simply instructed to write a description of the fan. Afterwards, participants were asked to rate the usefulness of the fan and answer demographic questions. Upon completion of the survey, participants were provided with the following text: "Thank you for participating in our study. The study session is now complete. **Please dispose of all research materials, including sample products, before exiting the lab.**" Upon leaving their individual breakout rooms, participants entered into the lab entryway which contained a large trashcan and three differentially colored recycling bins (labeled "PLASTIC", "METAL", and "BATTERIES"). Each recycling bin featured the universal symbol for recycling. Each container was lidded in order to prevent descriptive norm effects (Cialdini et al, 1990). Addressing a similar concern, participants within each session tended to finish at different times, and made their disposal decision on an individual basis with minimal social influence. The research assistants administering the study were instructed to respond to any questions regarding the disposal of the fan by simply answering, "Please dispose of the fan before exiting the lab." As specified in the pre-registration for this study, the observation of the presence or absence of a plastic fan body in a recycling bin served as the dependent variable for this experiment. An image of the laboratory recycling station is displayed in Figure 10.

Figure 10. Photograph of recycling station used in Study 7.

4.3.3 Analysis

I used log odds regression to test my hypothesis that performing the UUT with a broken product would increase the likelihood of recycling it. The model specified recycling as a binary dependent variable (0 = trash, 1 = recycle), with product condition (broken vs. functional), intervention (uses listing vs. control), and their interaction term serving as predictor variables. I also tested a simple mediation model to rule out an alternative account from prior recycling research that differences in recycling behaviour would be caused by differences in perceived usefulness following from elaboration on the number of uses associated with a product (Trudel and Argo, 2013). Additionally, I conducted a series of two-way ANOVAs to examine the effects of each condition on willingness to pay, attitude towards the product, likelihood of recommending the product to a friend, and a rating of the condition of the product. To calculate attitude towards the product, I averaged together each response to the 3-item measure of valence, liking, and favorability towards the product.

4.3.4 Results

A two-sample t-test between product condition (broken vs. functional) and subjective condition was statistically significant ($M_{functional} = 3.26$, $M_{broken} = 1.95$, $t(237) = 11.935$, $p < .001$), indicating that my manipulation was effective. Importantly, the log odds regression testing the effect of product condition, intervention, and their interaction on recycling was statistically significant ($\beta = 1.2914$, $p = .02$); the term representing the main effect of product condition in this model was also significant ($\beta = -1.2993$, $p < .001$). These results are displayed in Figure 11. The two-way ANOVA specifying product condition and intervention as independent variables and willingness to pay as the dependent variable did not yield statistical significance ($F(1, 235) = 1.737$, $p = .18$). The main effect of product condition on willingness to pay in this model was not significant ($F(1, 235) = 3.591$, $p = .06$). Similarly, the two-way ANOVA conducted to test the interaction effect of product condition and intervention on attitude towards the product was not significant ($F(1, 235) = .225$, $p = .64$), but there was a significant main effect of product condition on attitude towards the product ($M_{functional}$ = 4.82, M_{broken} = 2.87, $F(1, 235) = 106.676$, $p < .001$). Likewise, the two-way ANOVA for the interaction effect of product condition on likelihood of recommending the product to a friend was not significant ($F(1, 235) = 1.191$, $p = .28$), but the main effect was ($M_{functional}$ = 3.54, M_{broken} = 2.31, $F(1, 235) = 43.676$, $p < .001$). I conducted a two-way ANOVA investigating the effect of product condition and intervention on the perceived usefulness of the product, because a similar usage listing task was found to mediate recycling behaviour in a different study (Trudel and Argo, 2013). The interaction effect in this model was not significant ($F(1, 235) = .828$, $p = .36$), nor was the main effect of intervention ($F(1, 235) = .066$, $p = .80$). The main effect for product condition was significant ($F(1, 235) = 43.895$, $p < .001$). A t-test of product condition on perceived usefulness revealed that participants provided with functional fans perceived them as more useful compared to those given broken fans ($M_{functional}$ = 4.70, M_{broken} = 3.29, $t(237) = 6.64$, $p < .001$). Perceived usefulness may have played a role in the positive effect of performing the UUT in the functional product condition, consistent with the findings of Trudel and Argo (2013). However, a perceived usefulness account is insufficient to explain the differences in recycling behaviour between groups that I observed in this experiment, because I did not observe any effect of the UUT on the perceived usefulness of the broken product.

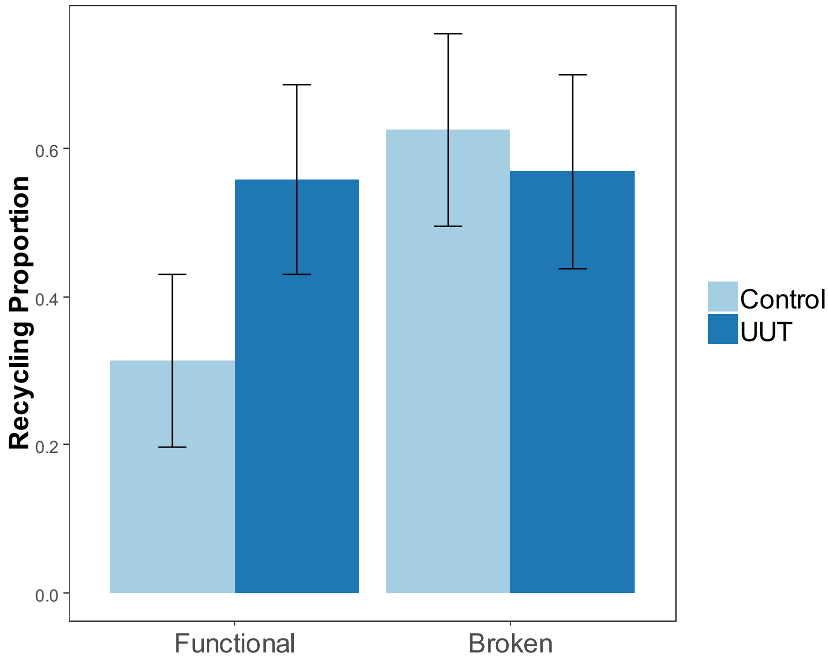


Figure 11. Bar plot of recycling behavior observed in Study 7. Interaction effect of product functionality and performing the unusual uses task (UUT) on the proportion of fans recycled. Error bars depict 95% confidence intervals.

4.3.5 Discussion

In this study I observed that, contrary to intuition, consumers were more likely to recycle fans that were broken than fans that were functional. Trudel and Argo (2013) observed that performing a uses listing task led to an increase in recycling, which apparently contradicts this finding. However, this discrepancy can be reasonably resolved by noting that their study used a simple object (piece of paper) as its stimulus, while mine used a compound object (electric fan). If my account is correct, the effects that I observed were mediated by participants mentally decomposing the stimulus into parts. This effect would not occur for a simple object, which by definition cannot be decomposed into meaningful units. If one were to evaluate my results independent of the theoretical account which I have developed in this paper, the results I obtained showing that participants recycled the broken fans at a greater rate than the functional fans would appear surprising. However, when one considers the companion concepts of chunk decomposition and constraint relaxation, these results fit logically within my theoretical framework. Providing participants with functional fans made the process of recycling the product less fluent because a) perceptual chunking prevented them from viewing the fan in terms of their component parts—a necessary step in the recycling process—and b) participants may have held an implicit constraint which specified that the fans should not be disassembled. Interestingly, participants in the functional fan condition that engaged in the UUT also exhibited increased recycling behaviour. This effect was not predicted under my theoretical framework, but it is consistent with research by Trudel and Argo (2013) which found that listing uses for recyclable goods increased recycling behaviour. One post-hoc explanation could be that participants that listed uses for the functional fan experienced cognitive dissonance during the disposal portion of the experiment (Festinger, 1957). If one has just elaborated on the utility of a product, it would be inconsistent to then throw the product into the garbage. This phenomenon is outside of the scope of this paper, however, and will not be addressed further.

Chapter 5: Discussion

5.1 Summary of Findings

In this dissertation, I presented seven studies exploring the effects of consumer interactions with broken products. In Study 1, I observed that participants are able to generate more novel ideas for a product—a wagon—that was broken relative to one that was functional. This effect was replicated in Studies 2 and 5, and replicated with another product—a lawn mower—in Study 4. In Study 2, I found that a similar effect on novel use generation could be found merely by providing participants with a disassembled version of the wagon. Studies 3 and 4 further investigated this relationship and demonstrated that chunking (and chunk decomposition) play a causal role in this effect. Furthermore, in Study 4 I observed that chunking precedes functional fixedness, and it is the disruption of this process that enables participants to generate more novel uses for broken products. Study 4 also demonstrated that novel use generation can be improved by using contextual variables to impede the chunking process (i.e., generating uses for a lawn mower in a desert). This result follows from the paired constraint model of novelty, which specifies that novelty follows from the simultaneous application of a constraint precluding search among conventional ideas while promoting search among unconventional ones (Stokes, 2007). Study 5 investigated a constraint relaxation account by examining whether generated uses for a broken product would yield downstream effects on the novelty of uses generated for a subsequently encountered product that was not broken. This account was not supported, indicating that the effect is localized to the product at hand and not caused by state level factors internal to the individual (e.g., mindset activation). In service of the motivating theme of this dissertation, Studies 6 and 7 examined the effects of interacting with broken products on disposal behaviour. Study 6 tested whether completing the UUT for a broken product (a wagon) would impact participants' self-reported likelihood of disposing of the product through several different means (throwing it in the trash, reusing it, repurposing it, selling it, or recycling it). The result of this study indicated that this exercise affected participants' willingness to recycle the product. In Study 7, I examined whether the finding reported in Study 6 would manifest in actual recycling behaviour. I conducted a laboratory recycling experiment in which participants either generated uses for or wrote a description about a handheld electric fan that was either broken or functional. I then observed whether participants threw their fan into the trash or recycled it. I observed that participants asked to write a description of a functional fan were the most likely to throw the fan in the trash as opposed to recycling it. I interpret this finding in light of the central role that chunking plays in the effect of product functionality on novel use generation. It appears that functional products tend to be chunked together in the mind, precluding disassembly. This account can explain both the phenomenon of functional fixedness and my finding that participants are more likely to recycle products that are broken.

Based on the research outlined above and the evidence collected in support of my hypotheses, I conclude that consumers are more creative with products that are broken. Furthermore, I argue that this is the case because consumers do not chunk broken products together in their mind, which disrupts functional fixedness and prevents its negative effects on novel use generation. This process can also be stated in an alternative way; consumers are less creative with functional products because they chunk them together, which facilitates functional fixedness and reduces capacity for novel use generation. According to Newell' and Simon's (1972) theory of human problem solving, consumers construct problem representations upon encountering task environments. The construction of a problem representation simultaneously creates a navigable problem space within which problem solving takes place. The particular problem representation chosen by the problem solver constrains the problem space and hence, the information available to the problem solver. Critically, the chunking that occurs when a problem solver encounters a task environment determines the nature of the information search (problem representation) as well as the information that is available to search (problem space). During the unusual uses task specifically, the way the target object is chunked constrains the uses that will be searched for as well as the body of information that will be searched within. If the target object is chunked together, this chunk acts as a constraint which precludes search among unconventional uses as well as a constraint which promotes search among conventional ones (Stokes, 2007). If the target is not chunked together, it can be thought of as a decomposed chunk, an uncomposed chunk, or even a pre-inventive structure (Finke et al, 1992), which acts as a constraint precluding search among conventional product uses and promoting search among unconventional product uses (Stokes, 2007).

5.2 Novel Insights into the Cause of Functional Fixedness

Based on my integration of theories on human problem solving and my research examining novel use generation with broken products, I have come to think of functional fixedness as an epiphenomenon of standard chunking processes that occur during problem solving. Chunking is implicated in each instance of functional fixedness as well as each successful intervention of it. Examples of such successful interventions include the generic parts technique (McAffrey, 2012), representational change (Duncker, 1945; Knoblich et al, 1999), incubation (Poincaré, 1908/1952, Smith, 1995), and attempting to solve a problem backwards by starting with the end and searching for the means (Duncker, 1945; Newell and Simon, 1972; Weatherford et al, 2021). In the generic parts technique, chunk decomposition occurs as the problem solver applies a production system which sequentially dismantles each chunk of information in the problem representation (McAffrey, 2012). In representational change theory, the problem representation is changed by either decomposing chunks or dissolving constraints, which can be thought of as compositions of procedural information which has been chunked together (Knoblich et al, 1999; Gobet et al, 2016). During incubation, chunks which were active during a previous unsuccessful solution attempt are allowed to dissolve over time as a result of memory decay (Smith and Blankenship, 1991; Smith, 1995). Attempting to solve problems by working backwards from the goal state can prevent chunking effects which would otherwise impede solution (Duncker, 1945; Newell and Simon, 1972). Indeed, disruption of chunking processes may be the "functional value" of the known successful interventions on functional fixedness, or the "means-by-which" each intervention is effective (Duncker, 1945).

5.3 Functional Fixedness as a Feature, not a Bug

The human mind is a highly complex information processing system that developed a capacity for chunking information into symbol structures, which are used as building blocks for sophisticated mental representations of problems encountered in the environment (Newell and Simon, 1972). These mental representations are used to construct and navigate within constrained problem spaces. This problem space, having been cued indirectly by the task environment, contains information that is well-suited for navigating within it. Some task environments, such as those studied in insight-problem solving experiments, can cause the construction of problem representations that cue problem spaces which do not contain the information required to reach the goal state. Psychologists have observed problem solvers navigating within these problem spaces and labeled it a human error— *functional fixedness.*

However, the cognitive processes at play while navigating the task environment may be perfectly executed and still be labeled functional fixedness. The locus of cause for what we call functional fixedness is arguably the task environment, not the problem solver, which is why I have observed differing sets of ideas as a result of applying changes to the task environment. While judges can interpret these uses afterwards based on criteria that are extrinsic to the task environment that the problem solver was operating within, this in no way suggests that their problem-solving procedures were irrational or inappropriately specified. Rather, encountering a broken product is a problem that is best solved by generating novel uses, and likewise encountering a functional product is a problem that is best solved by conventional uses. In either case, problem solving is working as intended and adapted to the problem at hand, consistent with what has been argued by Weisberg and Alba (1981).

5.4 Contributions to the Consumer Recycling Literature

Previously, Trudel and Argo (2013) observed that consumers were less likely to recycle products whose form had been distorted. The results I presented in Study 7 appear to contradict this claim, as I observed that participants were more likely to throw away products (handheld fans) that were functional. I contribute to the recycling literature and resolve this apparent contradiction by arguing that recycling behaviour differs depending on whether the product to be recycled is compound or is a primitive recyclable, such as the pieces of paper and aluminum cans featured as stimuli by Trudel and Argo (2013). Additionally, I contribute to research seeking to improve environmentally friendly disposal behaviours by exploring basic cognitive processes (DiGiacomo et al, 2018; Luo et al, 2019). Specifically, I show that reuse and recycling behaviours are impacted by chunking processes, functional fixedness, and the capacity to generate novel uses for objects.

5.5 Managerial Implications

In Chapter 1, I discussed a movement in North America called the right to repair movement. The success of this movement highlights the fact that people want to be able to use, reuse, and modify consumer products as they see fit. Many consumers are uncomfortable with external decision makers (e.g., manufacturing firms) deciding how they ought to use a product that is broken. In light of the findings that I have presented here, it seems that consumers view this circumstance as an opportunity to express creativity. This work can be placed within a broader literature of research showing that creativity is an important element of consumer behaviour, and firms stand to gain from acknowledging that consumption can be an outlet for creative expression (Moreau and Dahl, 2005; Dahl and Moreau, 2007; Sellier and Dahl, 2011, Mehta and Zhu, 2016).

Additionally, my research has important implications for product design. It strikes me that firms which are successful at present have survived selection pressures occurring at the level of the decision context of individual consumers. Successful manufacturers are able to design products that are optimized for consumer acquisition decisions. Some firms are able to optimize for consumption decisions. I propose that one avenue for differentiation in the future will be to optimize for disposal decisions. Many of the products proliferating throughout the marketplace are unfortunately designed with consumer acquisition in mind, with consumption and disposal considered afterwards or not at all. The result of this is a market full of product offerings which maximize acquisition without regard to how the product will be used and disposed of after acquisition. I argue that ethical consumers, socially responsible corporations, and public policy makers should advocate for designing products which are optimized for environmentally friendly disposal, whether that be through enduring product quality, facilitation of product repair, or making it easier to take the product apart during recycling. The research presented in this paper provides a ringing endorsement for the value of the latter suggestion in particular. Fortunately, this principle, referred to as "design for disassembly" is indeed gaining momentum among environmentally conscious product developers (Bogue, 2007; Rios et al, 2015).

5.6 Limitations and Future Research

Researchers, like artists, proceed with their craft by strategically self-imposing constraints (Stokes, 2007). In this dissertation, I have selected theories from the domain of problem solving as my source material for understanding the cognitive psychology of interacting with broken products. I chose the problem-solving domain because of its rich history of exploring how problem solvers are able to use objects in novel ways. In selecting this domain, I established a problem space that I could navigate in order to understand functional fixedness in the context of generating novel uses with broken products. This decision necessarily excluded other valuable bodies of information and theoretical tools that could have otherwise been used to understand this phenomenon. Simultaneously, this also leaves opportunities for future research looking to understand disposal decisions from different theoretical perspectives. Relevant theoretical perspectives which might be useful for contributing to the questions that I have not addressed in this paper include, but are not limited to, construal level theory (Trope and Liberman, 2010), affordance theory (Gibson, 1979), processing fluency theory (Reber et al, 2004), categorization (Rips, 1989), meaning maintenance (Heine et al, 2006), object concepts

(Malt and Johnson, 1992), psychological essentialism (Gelman and Echelbarger, 2019) and social influence (Cialdini et al, 1990). Furthermore, there are phenomenologically relevant aspects of interacting with broken products which deserve exploration, including emotional responses related to product failure (i.e., frustration), which may impact disposal decisions.

In addition to decisions regarding theoretical perspectives, I also made several decisions relating to experimental design that limit the generalizability of the results of this research. For example, when instructing participants to list uses in the UUT, I purposefully avoided wording related to creativity in order to approximate a candid product reuse context. Previous research on the UUT demonstrates that instructing participants to be creative does lead to more novel responses, and it is an open question whether or how instructing participants to be creative would affect novel use generation in the context of broken versus functional consumer products (Harrington, 1975). Additionally, when deciding how best to consolidate novelty judgments, I opted to use the negotiated agreement approach commonly used in qualitative research (Campbell et al, 2013). This approach possesses several advantages, including robust scoring given varying levels of judge expertise. In Studies 3 and 5, for example, agreement between judges prior to discussion was poor ($\alpha = .46$ and $\alpha = .64$, respectively). This suggests that discussion between judges enabled an improvement upon the validity and reliability of novelty scores that simply averaging scores together would not have provided. Nonetheless, research employing the consensual assessment technique traditionally consolidates judgments by averaging scores together (Amabile, 1982). The novelty scores used in Study 4 were generated by averaging judgments determined by independent peer judges, and replicated the results obtained using the negotiated agreement approach. However, it remains an open question whether or how scoring consolidation methods affect observed differences in the UUT. Another decision was made pertaining to how to operationalize the novelty construct. The analyses featured in the body of the dissertation placed an emphasis on the average novelty of each participant's set of responses to the UUT. One criticism of the use of average novelty as a dependent variable is that this metric may be sensitive to the traditional product uses one might expect to observe frequently in the control conditions (e.g., using a lawn mower for lawncare). In Appendix B, I address this concern by reporting the relative frequency of traditional vs. non-traditional uses for Studies 2, 4, and 5; furthermore, I provide the results of a battery of robustness checks for Studies 1, 2, 4, and 5 using alternative operationalizations of novelty. This investigation revealed that a) prior to quantifying the novelty of responses, there is a substantial difference in the categorical content of uses listings between control and treatment conditions, with responses in the control conditions being overwhelmingly populated by traditional uses, and b) the pattern of results is robust for alternative operationalizations of novelty (e.g., median novelty, top novelty).

Additionally, my research incorporated a limited number of products (wagon, lawn mower, fan). I have noted that one boundary condition for the effect of product functionality on novel use generation is whether the product is compound (i.e., can be decomposed into meaningful components). It is possible that there is some unknown variable at play in each of the stimuli that I have chosen that has some bearing on the effects that I observed. Furthermore, I do not have sufficient grounds to argue that the results which I observe would generalize outside of the populations which I sampled from (Henrich et al, 2010). Additionally, it is possible that effects hypothesized for Studies 3 and 5 were not supported due to issues with their experimental designs leading to a lower probability of observing a truly existing effect. These and other issues should be examined in future research.

5.7 Conclusion

In this dissertation, I have provided empirical evidence for the claim that consumers are able to generate more novel uses for products that are broken. This claim has relevant implications for how to encourage environmental consumer disposal behaviour as well as for how products should be designed in accordance with the psychological processes involved. To explore the psychological processes underlying this effect, I built upon theory from the literature on creative problem solving, which has noted that in certain circumstances consumers exhibit functional fixedness. I develop a theoretical account of functional fixedness as an epiphenomenon of chunking processes which occur during problem solving. I argue that participants of my studies yielded more novel uses for products that were broken because broken products are 'loose' chunks which disrupt the chunking process that normally occurs when interacting with functional products. Instead, participants develop a conceptual space in which search among conventional uses is precluded while search among unconventional uses is promoted. This account places elements of the task environment, such as product functionality, as fundamental to the phenomenon of functional fixedness.

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Appendices

Appendix A – Study Materials

A.1 Study 1 – Materials

Thank you for choosing to participate in our study. Today you will be asked to imagine your response to a product usage scenario.

[Functional Condition] Imagine that you are pulling a bright red wagon. You look at the wagon and notice that <u>the wheels are turning smoothly.</u>

[Broken Condition] Imagine that you are pulling a bright red wagon. You look at the wagon and notice that <u>the wheels are not turning at all.</u>

Please list as many uses for the wagon as you can think of.*

Please list as many uses for a pair of scissors as you can think of.*

----

*In Study 1, the wagon UUT and the Scissors UUT were presented in random order.

Earlier you were given a scenario about a red wagon. Which of the following is true about your red wagon?

- The wheels are turning smoothly
- The wheels are not turning at all
- I don't remember

What is your age?

What is your gender?

- Female
- Male
- Non-binary
- Prefer not to answer

What is your ethnic background?

- White/Caucasian
- Black/African American
- Hispanic or Latin
- First Nation
- East Asian (e.g., Chinese, Japanese, etc)
- South Asian (e.g., Indian, Pakistani, etc.)
- Middle Eastern
- Other

A.2 Study 2 – Materials

Thank you for choosing to participate in our study. Today you will be asked to imagine your response to a product usage scenario.

[Functional Condition] Imagine that you own the **functional wagon** pictured below.

[Parts Condition] Imagine that you own the **disassembled wagon** pictured below.

[Broken Condition] Imagine that you own the **broken wagon** pictured below.

Please list as many uses for **a brick** as you can think of.

On each of the following screens you will be provided with either 3 or 4 words that are somehow related to another unreported word. Your task is to identify and write down in the space provided the word that you think is related to all other mentioned words. Below are a couple of examples:

Examples:

1. Blank, White, Lines

The target word in this case would be “page”, as it is related to each of the three words listed above.

2. Water, Mississippi, Flow

The target word in this case would be “River”, as it is related to each of the three words listed above.

Each set of words will be presented on a separate screen. Once you figure out the answer, please write it down in the provided space and click “continue” to move onto the next screen. If you feel that you can’t solve the problem, enter “NA” and then click “continue”. **You have a maximum of 30 seconds to answer each question, at which point the screen will automatically move to the next question.**

--

boot/summer/ground ______

--

chamber/mask/natural ______

--

mill/tooth/dust ______

--

main/sweeper/light ______

--

pike/coat/signal ______

--

office/mail/hat ______

--

fly/clip/wall ______

--

age/mile/sand ______

--

catcher/food/hot ______

--

wagon/break/radio ______

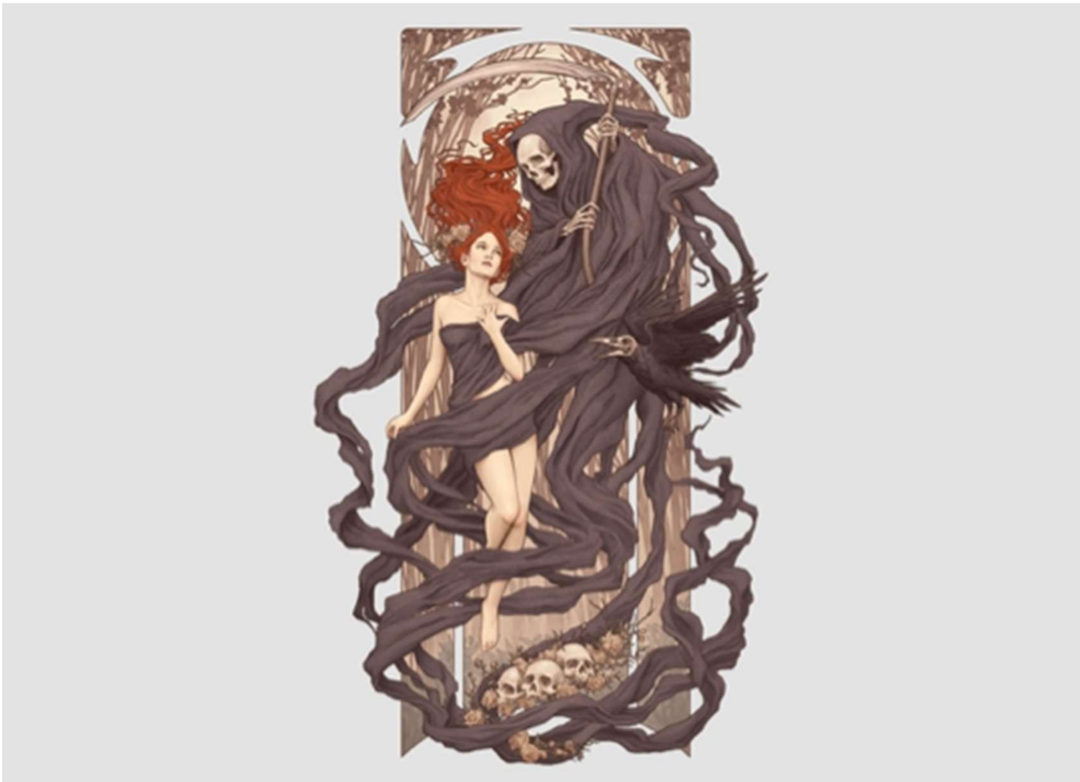
Many marketers are nowadays involving consumers directly in their business processes, for example, by asking consumers to submit an idea for a new product or design for a new t-shirt.

We'll present to you some designs and ask your willingness to submit a design when there is a chance to have the design printed on a real t-shirt.

Imagine that a T-shirt manufacturing company is inviting people to submit new and creative designs that could be printed on a T-shirt.

On the following screens we will show you some designs and would like you to indicate how likely you would be to submit the presented design. In this scenario, only the best, most creative designs should be submitted.

Please click next once you are ready to evaluate the designs.



How willing are you to submit this t-shirt design?

- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing

How willing are you to submit this t-shirt design?

- o Not willing at all
- o Slightly willing
- o Somewhat willing
- o Moderately willing
- o Quite willing
- o Very willing
- o Extremely willing

How willing are you to submit this t-shirt design?

- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing

How willing are you to submit this t-shirt design?

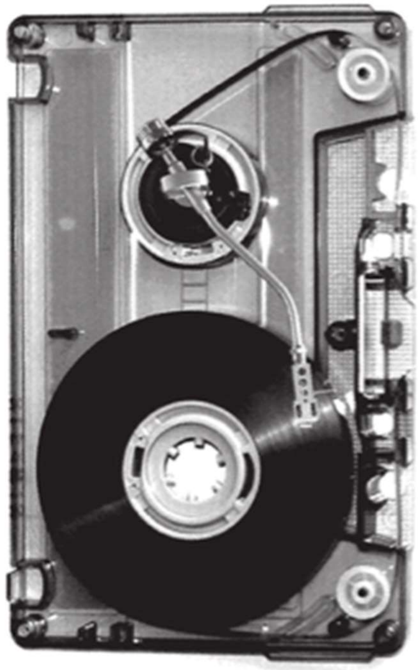
- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing

How willing are you to submit this t-shirt design?

- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing

How willing are you to submit this t-shirt design?

- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing

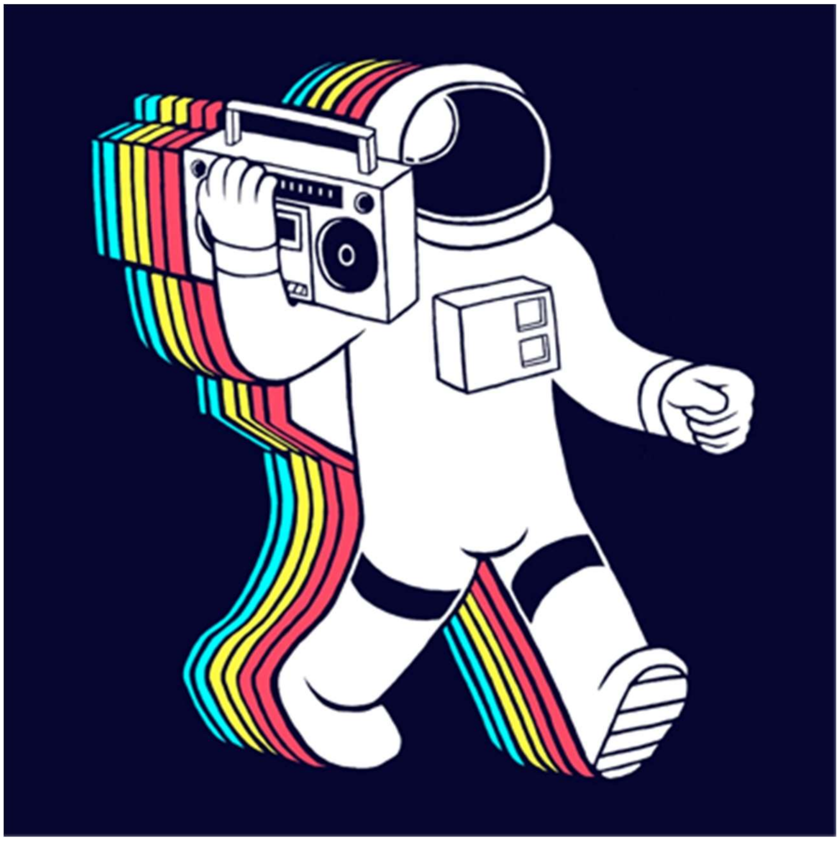


How willing are you to submit this t-shirt design?

- o Not willing at all
- o Slightly willing
- o Somewhat willing
- o Moderately willing
- o Quite willing
- o Very willing
- o Extremely willing

How willing are you to submit this t-shirt design?

- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing



How willing are you to submit this t-shirt design?

- o Not willing at all
- o Slightly willing
- o Somewhat willing
- o Moderately willing
- o Quite willing
- o Very willing
- o Extremely willing

How willing are you to submit this t-shirt design?

- Not willing at all
- Slightly willing
- Somewhat willing
- Moderately willing
- Quite willing
- Very willing
- Extremely willing

What is your age?

What is your gender?

- Female
- Male
- Non-binary
- Prefer not to answer

What is your ethnic background?

- White/Caucasian
- Black/African American
- Hispanic or Latin
- First Nation
- East Asian (e.g., Chinese, Japanese, etc)
- South Asian (e.g., Indian, Pakistani, etc.)
- Middle Eastern
- Other

A.3 Study 3 – Materials

Thank you for choosing to participate in our study. Today you will be asked to imagine your response to a product usage scenario.

Imagine that you own the **<u>wagon</u>** pictured below.

[Functional-Whole Condition]

[Functional-Parts Condition]

[Broken-Parts Condition]

[Broken-Whole Condition]

Please list as many uses for **<u>the wagon</u>** as you can think of.

How much would you be willing to pay (in CAD) for the wagon you were shown previously?

Please answer the following questions regarding the list of uses you generated for the wagon.

When I listed uses for the wagon...

I focused on the ways that wagons are typically used.

- o Strongly disagree
- o Disagree
- o Somewhat disagree
- o Neither agree nor disagree

- Somewhat agree
- Agree
- Strongly agree

I thought about uses for wagons that were new and unconventional.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I felt that it was okay to take the wagon apart.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I viewed the wagon as one whole object.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I viewed the wagon as several separate parts.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

When I attempt to solve a difficult problem, I tend to separate the problem into multiple sub-problems.

- Strongly disagree
- Disagree
- Somewhat disagree

- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

When I attempt to solve a difficult problem, I tend to step back and view the problem from a broader perspective.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Earlier you were given a scenario about a wagon. Please complete the following statements about the wagon you were shown.

The wagon was...

- Whole
- Separated into parts

The wagon appeared to be...

- o Functional/working properly
- o Dysfunctional/broken

[Analytic Versus Holistic Thinking Scale; 1 = Strongly disagree, 7 = Strongly agree]

1. Everything in the universe is somehow related to each other.
2. Nothing is unrelated.
3. Everything in the world is intertwined in a causal relationship.
4. Even a small change in any element of the universe can lead to significant alterations in other elements.
5. Any phenomenon has numerous numbers of causes, although some of the causes are not known.
6. Any phenomenon entails a numerous number of consequences, although some of them may not be known.
7. It is more desirable to take the middle ground than go to extremes.
8. When disagreement exists among people, they should search for ways to compromise and embrace everyone's opinions.
9. It is more important to find a point of compromise than to debate who is right/wrong when one's opinions conflict with other's opinions.

10. It is desirable to be in harmony, rather than in discord, with others of different opinions than one's own.
11. Choosing a middle ground in an argument should be avoided.
12. We should avoid going to extremes.
13. Every phenomenon in the world moves in predictable directions.
14. A person who is currently living a successful life will continue to stay successful.
15. An individual who is currently honest will stay honest in the future.
16. If an event is moving toward a certain direction, it will continue to move toward that direction.
17. Current situations can change at any time.
18. Future events are predictable based on present situations.
19. The whole, rather than its parts, should be considered in order to understand a phenomenon.
20. It is more important to pay attention to the whole than its parts.
21. The whole is greater than the sum of its parts.
22. It is more important to pay attention to the whole context rather than the details.
23. It is not possible to understand the parts without considering the whole picture.
24. We should consider the situation a person is faced with, as well as his/her personality, in order to understand one's behavior.

What is your age?

What is your gender?

- o Female
- o Male
- o Non-binary
- o Prefer not to answer

What is your ethnic background?

- o White/Caucasian
- o Black/African American
- o Hispanic or Latin
- o First Nation
- o East Asian (e.g., Chinese, Japanese, etc)
- o South Asian (e.g., Indian, Pakistani, etc.)
- o Middle Eastern
- o Other

A.4 Study 4 – Materials

Thank you for choosing to participate in our study. Today you will be asked to imagine your response to a product usage scenario.

Please read the following scenario and answer the questions that follow.

[Functional Lawn Condition]

Imagine that you have just moved to a new house. While unpacking, you find a **lawn mower** that you brought from your old house. You notice that this lawn mower is **functional** and **can be started with ease**.

After unpacking your lawn mower, you examine your property and see that the house you have moved to is in **a lush environment** and **has a lawn**.

[Functional Desert Condition]

Imagine that you have just moved to a new house. While unpacking, you find a **lawn mower** that you brought from your old house. You notice that this lawn mower is **functional** and **can be started with ease**.

After unpacking your lawn mower, you examine your property and realize that the house you have moved to is in **a desert environment** and **does not have a lawn.**

[Broken Lawn Condition]

Imagine that you have just moved to a new house. While unpacking, you find a **lawn mower** that you brought from your old house. You notice that this lawn mower is **broken** and **cannot be started at all**.

After unpacking your lawn mower, you examine your property and see that the house you have moved to is in **a lush environment** and **has a lawn**.

[Broken Desert Condition]

Imagine that you have just moved to a new house. While unpacking, you find a **lawn mower** that you brought from your old house. You notice that this lawn mower is **broken** and **cannot be started at all**.

After unpacking your lawn mower, you examine your property and realize that the house you have moved to is in **a desert environment** and **does not have a lawn**.

Please list as many uses for the lawn mower as you can think of.

Please answer the following questions regarding the list of uses you generated for the wagon.

When I listed uses for the wagon...

I focused on the ways that wagons are typically used.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I thought about uses for wagons that were new and unconventional.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I felt that it was okay to take the wagon apart.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I viewed the wagon as one whole object.

- Strongly disagree
- Disagree
- Somewhat disagree

- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I viewed the wagon as several separate parts.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Which of the following is true about the lawn mower you listed uses for?

- The lawn mower was functional
- The lawn mower was broken

Which of the following is true about the house you moved into in the scenario you read?

- The house was in a lush environment containing a lawn
- The house was in a desert environment and did not contain a lawn

How familiar are you with lawn mowers?

- o Very unfamiliar
- o Moderately unfamiliar
- o Slightly unfamiliar
- o Neutral
- o Slightly familiar
- o Moderately familiar
- o Very familiar

When I attempt to solve a difficult problem, I tend to separate the problem into multiple sub-problems.

- o Strongly disagree
- o Disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Agree
- o Strongly agree

When I attempt to solve a difficult problem, I tend to step back and view the problem from a broader perspective.

- o Strongly disagree

- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I feel comfortable taking things apart.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I prefer not to take things apart.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

It is okay to take things apart, even if there is no particular reason to do so.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

What is your age?

What is your gender?

- Female
- Male
- Non-binary
- Prefer not to answer

What is your ethnic background?

- White/Caucasian
- Black/African American
- Hispanic or Latin
- First Nation

- East Asian (e.g., Chinese, Japanese, etc)
- South Asian (e.g., Indian, Pakistani, etc.)
- Middle Eastern
- Other

A.5 Study 5 – Materials

Thank you for choosing to participate in our study. Today you will be asked questions about how you use products.

[Functional Condition] Imagine that you are pulling a red wagon. You look at the wagon and notice that <u>the wheels are turning smoothly.</u>

[Broken Condition] Imagine that you are pulling a red wagon. You look at the wagon and notice that <u>the wheels are not turning at all.</u>

Please list as many uses for the wagon as you can think of.

Please list as many uses for a silver pair of scissors as you can think of.

Please answer the following questions regarding the lists of uses that you generated in the previous tasks.

When I was thinking about uses for the **<u>wagon</u>**, in my mind I felt it was okay to take the **<u>wagon</u>** apart.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

When I was thinking about uses for the **<u>scissors</u>**, in my mind I felt it was okay to take the **<u>scissors</u>** apart.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Listing uses for the **scissors** was similar to listing uses for the **wagon**.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

When I listed uses for the **scissors**, I drew upon what I had learned from listing uses for the **wagon**.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Listing uses for the **wagon** had an impact on how I listed uses for the **scissors**.

- Strongly disagree
- Disagree

- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Which of the following is true about the red wagon you listed uses for?

- The wheels are turning smoothly
- The wheels are not turning at all
- I don't remember

You will next be asked to solve several word problems. Afterwards, you will be asked demographic questions and the study will be complete.

On each of the following screens you will be provided with either 3 or 4 words that are somehow related to another unreported word. Your task is to identify and write down in the space provided the word that you think is related to all other mentioned words. Below are a couple of examples:

Examples:

1. Blank, White, Lines

The target word in this case would be "page", as it is related to each of the three words listed above.

2. Water, Mississippi, Flow

The target word in this case would be "River", as it is related to each of the three words listed above.

Each set of words will be presented on a separate screen. Once you figure out the answer, please write it down in the provided space and click "continue" to move onto the next screen. If you feel that you can't solve the problem, enter "NA" and then click "continue". **You have a maximum of 30 seconds to answer each question, at which point the screen will automatically move to the next question.**

----

fish/mine/rush ______

----

basket/eight/snow ______

----

sense/courtesy/place ______

----

main/sweeper/light ______

----

peach/arm/tar ______

----

river/note/account ______

----

print/berry/bird ______

---

opera/hand/dish ______

---

fox/man/peep ______

---

way/board/sleep ______

What is your age?

What is your gender?

- o Female
- o Male
- o Non-binary
- o Prefer not to answer

What is your ethnic background?

- o White/Caucasian
- o Black/African American
- o Hispanic or Latin
- o First Nation
- o East Asian (e.g., Chinese, Japanese, etc)
- o South Asian (e.g., Indian, Pakistani, etc.)
- o Middle Eastern
- o Other

A.6 Study 6 – Materials

Thank you for choosing to participate in our study. Today you will be asked to imagine your response to a product usage scenario.

Thank you for choosing to participate in our study. Today you will be asked to imagine your response to a product usage scenario.

[Functional Condition] Imagine that you own the **functional wagon** pictured below.

[Broken Condition] Imagine that you own the **broken wagon** pictured below.

[Listing Condition] Please list as many uses for **the wagon** as you can think of.

How likely would you be to throw the wagon in the **trash**?

- Extremely unlikely
- Moderately unlikely
- Slightly unlikely
- Neither likely nor unlikely
- Slightly likely
- Moderately likely
- Extremely likely

How likely would you be to **reuse** the wagon?

- Extremely unlikely
- Moderately unlikely
- Slightly unlikely
- Neither likely nor unlikely
- Slightly likely
- Moderately likely
- Extremely likely

How likely would you be to **recycle** the wagon?

- Extremely unlikely
- Moderately unlikely
- Slightly unlikely
- Neither likely nor unlikely

- Slightly likely
- Moderately likely
- Extremely likely

How likely would you be to **sell** the wagon?

- Extremely unlikely
- Moderately unlikely
- Slightly unlikely
- Neither likely nor unlikely
- Slightly likely
- Moderately likely
- Extremely likely

How likely would you be to **repurpose** the wagon?

- Extremely unlikely
- Moderately unlikely
- Slightly unlikely
- Neither likely nor unlikely
- Slightly likely
- Moderately likely
- Extremely likely

How likely would you be to **break the wagon into parts**?

- Extremely unlikely

- Moderately unlikely
- Slightly unlikely
- Neither likely nor unlikely
- Slightly likely
- Moderately likely
- Extremely likely

What is your age?

What is your gender?

- Female
- Male
- Non-binary
- Prefer not to answer

What is your ethnic background?

- White/Caucasian
- Black/African American
- Hispanic or Latin
- First Nation
- East Asian (e.g., Chinese, Japanese, etc)
- South Asian (e.g., Indian, Pakistani, etc.)
- Middle Eastern
- Other

A.7 Study 7 – Materials

Thank you for choosing to participate in our study. Today you will be asked to evaluate a portable fan.

On your desk you will find a small sheet of paper with a number that we will use as an anonymous ID. Please type in the number below. If you do not have a number, please ask the research assistant to provide you with one.

On your desk underneath a sheet of paper you will find a portable fan. If you do not have a fan, please ask the research assistant to provide you with one.

Please take a moment to inspect and interact with the fan.

Please answer the following questions about the fan in its current state.

How much would you be willing to pay (in CAD) for this fan?

What is your overall evaluation of this fan?

Negative ○○○○○○○ Positive

Dislike ○○○○○○○ Like

Unfavorable ○○○○○○○ Favorable

How likely would you be to recommend this fan to a friend?

- o Extremely unlikely
- o Very unlikely
- o Somewhat unlikely
- o Neither likely nor unlikely
- o Somewhat likely
- o Very likely
- o Extremely likely

How would you rate the condition of this product?

- o Terrible
- o Poor
- o Average
- o Good
- o Excellent

[Control Condition] Please write a description of the fan.

[UUT Condition] Please list as many uses for the fan as you can think of.

Please rate the degree to which you agree/disagree with the following statement.

This fan is useful.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

What is your age?

What is your gender?

- Female
- Male
- Non-binary
- Prefer not to answer

What is your ethnic background?

- White/Caucasian
- Black/African American
- Hispanic or Latin
- First Nation
- East Asian (e.g., Chinese, Japanese, etc)
- South Asian (e.g., Indian, Pakistani, etc.)
- Middle Eastern
- Other

A.8 Coding Instructions Provided to Research Assistants

When rating novelty, ask yourself the following questions:

How original is this idea?

How novel is this idea?

How innovative is this idea?

How unique is this idea?

How atypical is this idea?

1 = Not novel at all

2 = Slightly novel

3 = Somewhat novel

4 = Moderately novel

5 = Quite novel

6 = Very novel

7 = Extremely novel

When rating appropriateness, ask yourself the following questions:

How effective is this idea at providing a solution to a problem or set of problems?

How practical is this idea?

How useful is this idea?

How appropriate is this idea?

1 = Not appropriate at all

2 = Slightly appropriate

3 = Somewhat appropriate

4 = Moderately appropriate

5 = Quite appropriate

6 = Very appropriate

7 = Extremely appropriate

Appendix B – Additional Tables of Statistics

B.1 Study 1 Tables of Descriptive Statistics

Study 1 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	1.71	0.84	1	1.5	4.5	3.5
Top Novelty (Wagon)	2.83	2.04	1	2.0	7.0	6.0
Fluency (Wagon)	3.95	2.06	1	3.0	11.0	10.0
Avg Novelty (Scissors)	1.77	0.84	1	1.5	7.0	6.0
Top Novelty (Scissors)	2.82	1.76	1	2.0	7.0	6.0
Fluency (Scissors)	4.34	2.16	1	4.0	14.0	13.0
Age	36.34	11.56	20	33.0	70.0	50.0
Duration (Seconds)	220.53	164.60	49	168.0	981.0	932.0

Study 1 – Descriptive Statistics – Functional Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	1.53	0.73	1	1.00	3.5	2.5
Top Novelty (Wagon)	2.53	2.00	1	1.00	7.0	6.0
Fluency (Wagon)	4.02	2.10	1	3.00	11.0	10.0
Avg Novelty (Scissors)	1.67	0.91	1	1.46	7.0	6.0
Top Novelty (Scissors)	2.62	1.74	1	2.00	7.0	6.0
Fluency (Scissors)	4.42	2.33	1	4.00	14.0	13.0
Age	36.93	12.42	20	34.00	69.0	49.0
Duration (Seconds)	224.42	183.30	53	166.50	981.0	928.0

Study 1 – Descriptive Statistics – Broken Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	1.90	0.90	1	1.67	4.5	3.5
Top Novelty (Wagon)	3.13	2.05	1	2.50	7.0	6.0
Fluency (Wagon)	3.88	2.04	1	3.00	9.0	8.0
Avg Novelty (Scissors)	1.87	0.77	1	1.55	4.0	3.0
Top Novelty (Scissors)	3.02	1.77	1	2.00	7.0	6.0
Fluency (Scissors)	4.27	1.98	1	4.00	10.0	9.0
Age	35.74	10.67	20	32.00	70.0	50.0
Duration (Seconds)	216.64	144.49	49	169.00	777.0	728.0

B.2 Study 2 – Tables of Descriptive Statistics

Study 2 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	3.20	1.14	1.0	3.00	6.00	5.00
Top Novelty (Wagon)	4.63	1.48	1.0	5.00	7.00	6.00
Fluency (Wagon)	4.29	2.01	0.0	4.00	14.00	14.00
Avg Appr (Wagon)	5.45	1.07	2.0	5.57	7.00	5.00
Top Appr (Wagon)	6.71	0.81	3.0	7.00	7.00	4.00
Flexibility (Wagon)	2.87	1.20	0.0	3.00	8.00	8.00
Avg Novelty (Brick)	2.44	0.90	1.0	2.40	4.86	3.86
Top Novelty (Brick)	4.33	1.92	1.0	5.00	7.00	6.00
Fluency (Brick)	4.45	2.11	1.0	4.00	11.00	10.00
Flexibility (Brick)	3.02	1.41	1.0	3.00	8.00	7.00
Avg Appr (Brick)	5.94	0.81	3.5	6.00	7.00	3.50
Top Appr (Brick)	6.97	0.28	4.0	7.00	7.00	3.00
RAT	2.47	2.45	0.0	2.00	10.00	10.00
High Orig Shirts	3.78	1.42	1.0	3.60	7.00	6.00
Low Orig Shirts	3.49	1.22	1.0	3.40	6.80	5.80
Age	33.63	10.73	19.0	31.00	73.00	54.00
Duration	616.19	1287.42	131.0	464.00	22101.00	21970.00

Study 2 – Descriptive Statistics – Whole (Functional) Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	2.59	0.72	1.00	2.60	5.00	4.00
Top Novelty (Wagon)	4.20	1.50	1.00	4.00	7.00	6.00
Fluency (Wagon)	4.73	1.96	1.00	5.00	11.00	10.00
Avg Appr (Wagon)	5.82	0.86	3.75	5.91	7.00	3.25
Top Appr (Wagon)	6.97	0.16	6.00	7.00	7.00	1.00
Flexibility (Wagon)	2.94	1.16	1.00	3.00	8.00	7.00
Avg Novelty (Brick)	2.47	0.86	1.00	2.38	4.73	3.73
Top Novelty (Brick)	4.39	1.85	1.00	5.00	7.00	6.00
Fluency (Brick)	4.54	2.22	1.00	4.00	11.00	10.00
Flexibility (Brick)	3.12	1.44	1.00	3.00	8.00	7.00
Avg Appr (Brick)	5.88	0.81	4.00	5.89	7.00	3.00
Top Appr (Brick)	6.96	0.27	5.00	7.00	7.00	2.00
RAT	2.71	2.67	0.00	2.00	10.00	10.00
High Orig Shirts	3.61	1.42	1.00	3.40	6.80	5.80
Low Orig Shirts	3.52	1.22	1.00	3.40	6.20	5.20
Age	34.10	10.48	20.00	31.00	73.00	53.00
Duration	549.72	750.22	131.00	451.00	7867.00	7736.00

Study 2 – Descriptive Statistics – Parts Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	3.06	1.10	1.50	2.82	6.00	4.50
Top Novelty (Wagon)	4.64	1.52	2.00	5.00	7.00	5.00
Fluency (Wagon)	4.55	1.97	1.00	4.00	12.00	11.00
Avg Appr (Wagon)	5.52	1.00	2.25	5.54	7.00	4.75
Top Appr (Wagon)	6.85	0.50	4.00	7.00	7.00	3.00
Flexibility (Wagon)	3.04	1.23	1.00	3.00	6.00	5.00
Avg Novelty (Brick)	2.40	0.91	1.00	2.40	4.57	3.57
Top Novelty (Brick)	4.35	2.05	1.00	5.00	7.00	6.00
Fluency (Brick)	4.60	2.19	1.00	4.00	11.00	10.00
Flexibility (Brick)	3.05	1.51	1.00	3.00	7.00	6.00
Avg Appr (Brick)	5.98	0.79	4.00	6.00	7.00	3.00
Top Appr (Brick)	6.98	0.19	5.00	7.00	7.00	2.00
RAT	2.51	2.42	0.00	2.00	10.00	10.00
High Orig Shirts	3.74	1.32	1.20	3.60	6.60	5.40
Low Orig Shirts	3.46	1.21	1.00	3.40	6.20	5.20
Age	33.03	10.93	19.00	30.00	67.00	48.00
Duration	731.95	2073.26	185.00	458.00	22101.00	21916.00

Study 2 – Descriptive Statistics – Broken Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	3.98	1.10	1.0	4.00	6.00	5.00
Top Novelty (Wagon)	5.07	1.29	1.0	5.00	7.00	6.00
Fluency (Wagon)	3.57	1.93	0.0	3.00	14.00	14.00
Avg Appr (Wagon)	5.00	1.16	2.0	5.00	7.00	5.00
Top Appr (Wagon)	6.28	1.20	3.0	7.00	7.00	4.00
Flexibility (Wagon)	2.64	1.18	0.0	3.00	7.00	7.00
Avg Novelty (Brick)	2.44	0.93	1.0	2.25	4.86	3.86
Top Novelty (Brick)	4.24	1.89	1.0	4.00	7.00	6.00
Fluency (Brick)	4.21	1.91	1.0	4.00	10.00	9.00
Flexibility (Brick)	2.90	1.27	1.0	3.00	6.00	5.00
Avg Appr (Brick)	5.97	0.83	3.5	6.00	7.00	3.50
Top Appr (Brick)	6.95	0.35	4.0	7.00	7.00	3.00
RAT	2.19	2.23	0.0	2.00	9.00	9.00
High Orig Shirts	3.98	1.52	1.0	4.00	7.00	6.00
Low Orig Shirts	3.50	1.25	1.0	3.40	6.80	5.80
Age	33.76	10.85	19.0	31.00	69.00	50.00
Duration	565.38	286.47	136.0	502.00	1837.00	1701.00

B.3 Study 3 – Tables of Descriptive Statistics

Study 3 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.56	0.86	1.00	2.50	6.00	5.00
Top Novelty	3.73	1.49	1.00	3.00	7.00	6.00
Fluency	3.74	1.83	1.00	4.00	12.00	11.00
Avg Frequency	0.08	0.05	0.00	0.07	0.20	0.20
Avg Appr	5.64	0.90	1.33	5.80	7.00	5.67
Top Appr	6.64	0.69	2.00	7.00	7.00	5.00
WTP	20.35	18.87	0.00	15.00	100.00	100.00
Functional Fixedness	4.78	1.38	1.00	5.00	7.00	6.00
Chunk Decomposition	2.90	1.43	1.00	2.67	7.00	6.00
Reductive Solving	4.78	1.43	1.00	5.00	7.00	6.00
Holistic Solving	5.11	1.33	1.00	5.00	7.00	6.00
Analytic-Holistic	4.74	0.48	3.38	4.71	6.38	3.00
Age	20.08	1.37	16.00	20.00	27.00	11.00
Duration	544.43	1267.10	68.00	325.00	19607.00	19539.00

Study 3 – Descriptive Statistics – Broken Parts Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.70	0.99	1.00	2.67	6.00	5.00
Top Novelty	3.96	1.63	1.00	4.00	7.00	6.00
Fluency	3.87	1.96	1.00	4.00	11.00	10.00
Avg Frequency	0.08	0.05	0.00	0.07	0.20	0.20
Avg Appr	5.50	0.99	3.00	5.69	7.00	4.00
Top Appr	6.59	0.71	3.00	7.00	7.00	4.00
WTP	22.60	23.43	0.00	15.00	100.00	100.00
Functional Fixedness	4.46	1.42	1.00	4.50	7.00	6.00
Chunk Decomposition	3.37	1.57	1.00	3.00	7.00	6.00
Reductive Solving	4.74	1.48	1.00	5.00	7.00	6.00
Holistic Solving	5.15	1.32	1.00	5.00	7.00	6.00
Analytic-Holistic	4.73	0.48	3.62	4.71	5.83	2.21
Age	19.98	1.20	16.00	20.00	23.00	7.00
Duration	522.31	798.43	68.00	318.50	6098.00	6030.00

Study 3 – Descriptive Statistics – Functional Parts Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.65	0.98	1.00	2.50	5.67	4.67
Top Novelty	3.88	1.68	1.00	3.00	7.00	6.00
Fluency	3.56	1.76	1.00	3.00	9.00	8.00
Avg Frequency	0.09	0.05	0.00	0.07	0.20	0.20
Avg Appr	5.51	1.10	1.33	5.67	7.00	5.67
Top Appr	6.60	0.82	2.00	7.00	7.00	5.00
WTP	21.34	16.05	0.00	20.00	75.00	75.00
Functional Fixedness	4.72	1.39	1.50	4.50	7.00	5.50
Chunk Decomposition	3.09	1.43	1.00	3.00	6.33	5.33
Reductive Solving	4.69	1.35	2.00	5.00	7.00	5.00
Holistic Solving	4.89	1.42	1.00	5.00	7.00	6.00
Analytic-Holistic	4.76	0.51	3.79	4.75	5.92	2.13
Age	20.15	1.38	18.00	20.00	25.00	7.00
Duration	508.29	758.94	93.00	320.00	5932.00	5839.00

Study 3 – Descriptive Statistics – Broken Whole Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.50	0.71	1.00	2.50	4.67	3.67
Top Novelty	3.55	1.22	1.00	3.00	7.00	6.00
Fluency	3.70	1.79	1.00	3.00	11.00	10.00
Avg Frequency	0.08	0.05	0.00	0.07	0.20	0.20
Avg Appr	5.72	0.73	3.25	6.00	7.00	3.75
Top Appr	6.71	0.60	5.00	7.00	7.00	2.00
WTP	17.28	16.17	0.00	15.00	70.00	70.00
Functional Fixedness	4.93	1.25	2.00	5.00	7.00	5.00
Chunk Decomposition	2.69	1.33	1.00	2.33	6.00	5.00
Reductive Solving	4.82	1.47	2.00	5.00	7.00	5.00
Holistic Solving	5.16	1.30	2.00	5.00	7.00	5.00
Analytic-Holistic	4.75	0.42	3.88	4.71	5.96	2.08
Age	20.12	1.28	18.00	20.00	26.00	8.00
Duration	515.13	1056.76	93.00	325.00	9696.00	9603.00

Study 3 – Descriptive Statistics – Functional Whole Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.41	0.68	1.00	2.33	3.80	2.80
Top Novelty	3.51	1.32	1.00	3.00	7.00	6.00
Fluency	3.79	1.80	1.00	4.00	12.00	11.00
Avg Frequency	0.09	0.05	0.01	0.08	0.20	0.19
Avg Appr	5.82	0.70	4.00	6.00	7.00	3.00
Top Appr	6.68	0.61	5.00	7.00	7.00	2.00
WTP	19.91	18.23	0.00	15.00	100.00	100.00
Functional Fixedness	5.01	1.39	1.00	5.00	7.00	6.00
Chunk Decomposition	2.46	1.20	1.00	2.00	6.00	5.00
Reductive Solving	4.84	1.42	1.00	5.00	7.00	6.00
Holistic Solving	5.21	1.30	1.00	6.00	7.00	6.00
Analytic-Holistic	4.72	0.50	3.38	4.75	6.38	3.00
Age	20.08	1.59	18.00	19.00	27.00	9.00
Duration	624.23	1988.00	114.00	333.00	19607.00	19493.00

B.4 Study 4 – Descriptive Statistics

Study 4 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.85	0.67	1.92	2.79	5.58	3.67
Top Novelty	3.37	0.94	1.92	3.42	5.58	3.67
Flexibility	2.18	1.21	1.00	2.00	6.00	5.00
Fluency	2.95	1.70	1.00	3.00	10.00	9.00
Avg Frequency	0.08	0.06	0.00	0.06	0.20	0.20
FF	4.58	1.48	1.00	4.50	7.00	6.00
Chunk Decomposition	3.60	1.76	1.00	3.33	7.00	6.00
Chunking	4.40	1.76	1.00	4.67	7.00	6.00
Familiarity	5.41	1.42	1.00	6.00	7.00	6.00
Reductive Solving	4.65	1.36	1.00	5.00	7.00	6.00
Holistic Solving	5.29	1.14	1.00	5.00	7.00	6.00
Disassembly	4.10	1.37	1.00	4.00	7.00	6.00
Age	40.49	13.56	18.00	38.00	77.00	59.00
Duration	312.00	266.14	75.00	243.50	3634.00	3559.00

Study 4 – Descriptive Statistics – Broken Desert Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	3.14	0.55	1.92	3.14	4.42	2.50
Top Novelty	3.69	0.73	1.92	3.83	4.92	3.00
Flexibility	2.41	1.18	1.00	2.00	6.00	5.00
Fluency	3.00	1.61	1.00	3.00	8.00	7.00
Avg Frequency	0.05	0.04	0.00	0.04	0.20	0.20
FF	4.06	1.45	1.00	4.00	7.00	6.00
Chunk Decomposition	4.52	1.66	1.00	5.00	7.00	6.00
Chunking	3.48	1.66	1.00	3.00	7.00	6.00
Familiarity	5.23	1.37	1.00	6.00	7.00	6.00
Reductive Solving	4.82	1.30	1.00	5.00	7.00	6.00
Holistic Solving	5.29	1.13	1.00	6.00	7.00	6.00
Disassembly	4.21	1.29	1.67	4.00	7.00	5.33
Age	39.31	12.38	18.00	38.00	66.00	48.00
Duration	309.01	199.57	85.00	244.00	1085.00	1000.00

Study 4 – Descriptive Statistics – Functional Desert

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	3.03	0.78	1.92	2.98	5.58	3.67
Top Novelty	3.56	0.95	1.92	3.58	5.58	3.67
Flexibility	2.28	1.17	1.00	2.00	5.00	4.00
Fluency	3.08	1.83	1.00	3.00	10.00	9.00
Avg Frequency	0.05	0.05	0.00	0.05	0.20	0.20
FF	4.15	1.29	1.50	4.00	6.50	5.00
Chunk Decomposition	3.70	1.74	1.00	3.67	7.00	6.00
Chunking	4.30	1.74	1.00	4.33	7.00	6.00
Familiarity	5.50	1.33	1.00	6.00	7.00	6.00
Reductive Solving	4.48	1.38	1.00	5.00	7.00	6.00
Holistic Solving	5.23	0.96	2.00	5.00	7.00	5.00
Disassembly	4.10	1.34	1.00	4.00	7.00	6.00
Age	41.29	14.48	20.00	36.50	75.00	55.00
Duration	320.46	222.02	75.00	272.00	1350.00	1275.00

Study 4 – Descriptive Statistics – Broken Lawn

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.77	0.60	1.92	2.64	4.21	2.29
Top Novelty	3.29	0.97	1.92	3.00	5.58	3.67
Flexibility	2.42	1.30	1.00	2.00	6.00	5.00
Fluency	3.10	1.79	1.00	3.00	10.00	9.00
Avg Frequency	0.08	0.06	0.00	0.06	0.20	0.19
FF	4.71	1.51	1.00	5.00	7.00	6.00
Chunk Decomposition	4.09	1.52	1.00	4.67	6.67	5.67
Chunking	3.91	1.52	1.33	3.33	7.00	5.67
Familiarity	5.27	1.55	1.00	6.00	7.00	6.00
Reductive Solving	5.08	1.10	2.00	5.00	7.00	5.00
Holistic Solving	5.42	1.06	2.00	5.00	7.00	5.00
Disassembly	4.24	1.31	1.33	4.00	7.00	5.67
Age	39.77	13.39	21.00	38.00	71.00	50.00
Duration	370.65	428.97	121.00	248.00	3634.00	3513.00

Study 4 – Descriptive Statistics – Functional Lawn

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty	2.47	0.52	1.92	2.39	4.12	2.21
Top Novelty	2.96	0.94	1.92	2.92	4.92	3.00
Flexibility	1.71	1.10	1.00	1.00	5.00	4.00
Fluency	2.67	1.61	1.00	2.00	8.00	7.00
Avg Frequency	0.12	0.06	0.00	0.11	0.20	0.19
FF	5.35	1.29	2.00	5.50	7.00	5.00
Chunk Decomposition	2.25	1.13	1.00	2.00	5.00	4.00
Chunking	5.75	1.13	3.00	6.00	7.00	4.00
Familiarity	5.61	1.44	1.00	6.00	7.00	6.00
Reductive Solving	4.33	1.48	1.00	5.00	7.00	6.00
Holistic Solving	5.25	1.35	1.00	6.00	7.00	6.00
Disassembly	3.88	1.51	1.00	4.00	7.00	6.00
Age	41.51	14.03	20.00	39.50	77.00	57.00
Duration	264.02	179.32	76.00	221.00	1594.00	1518.00

B.5 Study 5 – Descriptive Statistics

Study 5 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	2.25	1.05	1.00	2.00	6	5.00
Top Novelty (Wagon)	3.32	1.68	1.00	3.00	7	6.00
Avg Appr (Wagon)	5.95	1.04	2.00	6.25	7	5.00
Top Appr (Wagon)	6.76	0.66	2.00	7.00	7	5.00
Fluency (Wagon)	3.57	1.96	1.00	3.00	13	12.00
Flexibility (Wagon)	3.47	1.29	2.00	3.00	12	10.00
Avg Novelty (Scissors)	1.82	0.78	1.00	1.67	5	4.00
Top Novelty (Scissors)	3.14	1.77	1.00	3.00	7	6.00
Avg Appr (Scissors)	6.43	0.59	3.75	6.50	7	3.25
Top Appr (Scissors)	6.99	0.10	6.00	7.00	7	1.00
Fluency (Scissors)	4.04	2.05	1.00	4.00	12	11.00
Flexibility (Scissors)	4.48	1.49	2.00	4.00	11	9.00
Wagon Constraint	3.23	1.85	1.00	3.00	7	6.00
Scissors Constraint	3.02	1.79	1.00	2.00	7	6.00
Transfer	3.19	1.34	1.00	3.00	7	6.00
RAT	2.00	2.51	0.00	1.00	10	10.00
Age	19.84	1.53	17.00	19.00	36	19.00
Duration	3410.38	34532.10	121.00	410.00	578160	578039.00

Study 5 – Descriptive Statistics – Functional Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	1.83	0.76	1.00	1.67	4.0	3.00
Top Novelty (Wagon)	2.97	1.70	1.00	3.00	7.0	6.00
Avg Appr (Wagon)	6.13	0.94	3.33	6.50	7.0	3.67
Top Appr (Wagon)	6.93	0.28	5.00	7.00	7.0	2.00
Fluency (Wagon)	3.73	1.91	1.00	3.00	13.0	12.00
Flexibility (Wagon)	3.38	1.17	2.00	3.00	8.0	6.00
Avg Novelty (Scissors)	1.83	0.83	1.00	1.60	4.5	3.50
Top Novelty (Scissors)	3.22	1.93	1.00	3.00	7.0	6.00
Avg Appr (Scissors)	6.45	0.60	4.17	6.59	7.0	2.83
Top Appr (Scissors)	6.99	0.08	6.00	7.00	7.0	1.00
Fluency (Scissors)	4.06	2.02	1.00	4.00	12.0	11.00
Flexibility (Scissors)	4.51	1.43	2.00	4.00	10.0	8.00
Wagon Constraint	2.70	1.67	1.00	2.00	7.0	6.00
Scissors Constraint	2.88	1.82	1.00	2.00	7.0	6.00
Transfer	3.12	1.31	1.00	3.00	7.0	6.00
RAT	2.07	2.66	0.00	1.00	10.0	10.00
Age	19.92	1.86	17.00	19.00	36.0	19.00
Duration	5536.30	48661.30	124.00	402.50	578160.0	578036.00

Study 5 – Descriptive Statistics – Broken Condition

Variable	Mean	SD	Min	Median	Max	Range
Avg Novelty (Wagon)	2.67	1.13	1.00	2.75	6	5.00
Top Novelty (Wagon)	3.66	1.58	1.00	4.00	7	6.00
Avg Appr (Wagon)	5.78	1.10	2.00	6.00	7	5.00
Top Appr (Wagon)	6.59	0.85	2.00	7.00	7	5.00
Fluency (Wagon)	3.41	2.00	1.00	3.00	13	12.00
Flexibility (Wagon)	3.55	1.40	2.00	3.00	12	10.00
Avg Novelty (Scissors)	1.81	0.72	1.00	1.75	5	4.00
Top Novelty (Scissors)	3.06	1.61	1.00	3.00	7	6.00
Avg Appr (Scissors)	6.42	0.58	3.75	6.50	7	3.25
Top Appr (Scissors)	6.99	0.11	6.00	7.00	7	1.00
Fluency (Scissors)	4.01	2.08	1.00	4.00	11	10.00
Flexibility (Scissors)	4.44	1.56	2.00	4.00	11	9.00
Wagon Constraint	3.75	1.87	1.00	3.00	7	6.00
Scissors Constraint	3.16	1.76	1.00	3.00	7	6.00
Transfer	3.26	1.37	1.00	3.00	7	6.00
RAT	1.94	2.36	0.00	1.00	9	9.00
Age	19.76	1.12	18.00	20.00	25	7.00
Duration	1325.62	6230.26	121.00	417.00	63043	62922.00

B.6 Study 6 – Descriptive Statistics

Study 6 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Trash	3.68	2.18	1	3	7	6
Reuse	5.12	1.87	1	6	7	6
Recycle	4.76	1.72	1	5	7	6
Sell	3.64	2.03	1	4	7	6
Repurpose	5.01	1.70	1	5	7	6
Parts	3.28	2.03	1	3	7	6
Age	35.95	11.73	19	33	73	54
Duration	247.04	821.01	38	131	14227	14189

Study 6 – Descriptive Statistics – Broken Control Condition

Variable	Mean	SD	Min	Median	Max	Range
Trash	4.87	1.89	1	5	7	6
Reuse	4.06	1.91	1	5	7	6
Recycle	4.27	1.82	1	5	7	6
Sell	2.82	1.82	1	2	7	6
Repurpose	4.55	1.97	1	5	7	6
Parts	3.72	2.03	1	4	7	6
Age	35.91	11.95	19	33	70	51
Duration	147.32	194.24	38	100	1663	1625

Study 6 – Descriptive Statistics – Whole Control Condition

Variable	Mean	SD	Min	Median	Max	Range
Trash	2.59	1.81	1	2.0	7	6
Reuse	5.91	1.29	1	6.0	7	6
Recycle	4.70	1.58	1	5.0	7	6
Sell	4.62	1.67	1	5.0	7	6
Repurpose	5.28	1.47	1	6.0	7	6
Parts	2.84	1.87	1	2.0	7	6
Age	35.66	11.73	20	31.5	71	51
Duration	163.34	276.06	41	100.5	2642	2601

Study 6 – Descriptive Statistics – Broken Usage Listing Condition

Variable	Mean	SD	Min	Median	Max	Range
Trash	4.94	1.73	1	5	7	6
Reuse	4.21	1.98	1	5	7	6
Recycle	4.96	1.70	1	5	7	6
Sell	2.76	1.98	1	2	7	6
Repurpose	4.79	1.76	1	5	7	6
Parts	4.11	1.96	1	5	7	6
Age	36.35	11.33	19	35	70	51
Duration	420.61	1525.47	47	170	14227	14180

Study 6 – Descriptive Statistics – Whole Usage Listing Condition

Variable	Mean	SD	Min	Median	Max	Range
Trash	2.35	1.82	1	2	7	6
Reuse	6.28	0.99	2	7	7	5
Recycle	5.12	1.70	1	6	7	6
Sell	4.31	1.94	1	5	7	6
Repurpose	5.40	1.44	1	6	7	6
Parts	2.41	1.82	1	2	7	6
Age	35.90	12.12	21	33	73	52
Duration	255.77	414.43	65	163	3837	3772

B.7 Study 7 – Descriptive Statistics

Study 7 – Descriptive Statistics – All Conditions

Variable	Mean	SD	Min	Median	Max	Range
Recycle	0.51	0.50	0	1	1	1
WTP	6.44	10.26	0	5	100	100
Attitude	3.89	1.76	1	4	7	6
WOM	2.95	1.56	1	3	7	6
Useful	4.03	1.78	1	5	7	6
Age	20.33	1.62	18	20	34	16
Duration	3146.07	1429.65	113	2905	9180	9067

Study 7 – Descriptive Statistics – Broken Control Condition

Variable	Mean	SD	Min	Median	Max	Range
Recycle	0.62	0.49	0	1.0	1.00	1.00
WTP	4.24	4.43	0	3.0	15.00	15.00
Attitude	2.89	1.26	1	3.0	5.33	4.33
WOM	2.16	1.11	1	2.0	5.00	4.00
Useful	3.21	1.77	1	3.0	7.00	6.00
Age	20.45	1.22	18	20.0	23.00	5.00
Duration	3445.11	1825.23	1295	2946.5	9180.00	7885.00

Study 7 – Descriptive Statistics – Functional Control Condition

Variable	Mean	SD	Min	Median	Max	Range
Recycle	0.31	0.47	0	0.00	1	1
WTP	8.48	12.82	0	5.00	100	100
Attitude	4.93	1.54	1	5.17	7	6
WOM	3.59	1.65	1	4.00	7	6
Useful	4.81	1.51	1	5.00	7	6
Age	20.41	1.53	19	20.00	26	7
Duration	2875.98	1311.50	113	2626.50	6528	6415

Study 7 – Descriptive Statistics – Broken Usage Listing Condition

Variable	Mean	SD	Min	Median	Max	Range
Recycle	0.57	0.50	0	1.00	1	1
WTP	6.00	14.23	0	4.00	100	100
Attitude	2.84	1.55	1	2.67	7	6
WOM	2.45	1.38	1	2.00	5	4
Useful	3.36	1.73	1	3.00	7	6
Age	20.03	1.24	18	20.00	24	6
Duration	3086.74	1347.09	828	2905.00	6839	6011

Study 7 – Descriptive Statistics – Functional Usage Listing Condition

Variable	Mean	SD	Min	Median	Max	Range
Recycle	0.56	0.50	0	1	1	1
WTP	6.75	5.03	0	5	30	30
Attitude	4.71	1.47	1	5	7	6
WOM	3.48	1.51	1	3	7	6
Useful	4.57	1.55	1	5	7	6
Age	20.44	2.23	18	20	34	16
Duration	3211.31	1163.92	1019	2983	6942	5923

B.8 Robustness Checks

Robustness Checks

In this dissertation, I have chosen to focus primarily on average novelty scores for each use listed by participants in an unusual uses task. For Studies 1, 2, 3, and 5, these scores were created by having two judges assign scores independently and afterwards discussing discrepancies between their scores until a consensus is reached for each use. One criticism of the use of average novelty is that it may systematically bias novelty scores between conditions. For example, a plausible confounding account would be that participants in the functional condition list traditional product uses and afterwards list novel product uses. If this were the case, observed differences between groups would be attributable not to the independent variable (product functionality), but to the use of average novelty as a dependent variable.

I address this alternative account in two ways. First, I present the relative proportions of traditional and non-traditional product uses by condition for Studies 2, 4, and 5. These proportions provide contextual information regarding which types of uses each group of participants focused on. Importantly, these proportions are consistent with the theoretical framework outlined in the body of the dissertation. Namely, they reflect the notion that participants in the functional conditions overwhelmingly fixated on traditional product uses, with differences between groups representing genuine differences in topical content. In contrast, these proportions do not corroborate an account that participants first listed traditional uses and afterwards listed novel uses. Second, I provide the results of statistical tests using several other relevant metrics: top novelty, median novelty, novelty of first use listed, novelty of last use listed and, for convenience, number of uses generated. The results of these statistical tests enable the reader to view the effects of product functionality from several different perspectives. Furthermore, each operationalization of novelty presents its own trade-offs relative to average novelty, including differences in sensitivity to extreme values and measurement of the central tendency of participants' response sets. Broadly, these results indicate a robust pattern in the data that are consistent with the conclusions drawn in the body of the dissertation.

Study 1

Table of Significance Tests

Variable	$\mathbf{M_{broken}}$	$\mathbf{M_{functional}}$	***t***	***df***	***p***
Average Novelty	1.90	1.53	2.94	162.33	.004
Top Novelty	3.13	2.53	1.92	169.88	.06
Median Novelty	1.67	1.31	2.81	149.94	.005
First Use Novelty	1.30	1.14	1.57	169.07	.12
Last Use Novelty	2.28	1.93	1.33	167.94	.19
Fluency	3.88	4.02	-0.44	169.86	.66

Study 2

Table of Proportions of Traditional Uses

	Traditional Uses	Non-Traditional Uses
Broken	28%	72%
Parts	60%	40%
Functional	70%	30%

Table of Significance Tests

Variable	M_{broken}	M_{parts}	$M_{functional}$	F	df	p
Average Novelty	3.98	3.06	2.59	54.4	2, 323	<.001
Top Novelty	5.07	4.64	4.20	9.69	2, 323	<.001
Median Novelty	3.97	2.95	2.47	50.06	2, 323	<.001
First Use Novelty	3.92	2.51	2.16	58.47	2, 323	<.001
Last Use Novelty	4.02	3.16	3.09	10.84	2, 323	<.001
Fluency	3.61	4.55	4.73	10.4	2, 324	<.001
Flexibility	2.64	3.04	2.94	3.27	2, 324	.04

Study 4

Table of Proportions of Traditional Uses—Product Type

	Traditional Uses	Non-Traditional Uses
Broken	20%	80%
Functional	49%	51%

Table of Proportions of Traditional Uses—Environment Type

	Traditional Uses	Non-Traditional Uses
Desert	22%	78%
Lawn	49%	51%

Table of Averages by Condition

Variable	$\mathbf{M_{broken\text{-}desert}}$	$\mathbf{M_{broken\text{-}lawn}}$	$\mathbf{M_{functional\text{-}desert}}$	$\mathbf{M_{functional\text{-}lawn}}$
Average Novelty	3.14	2.77	3.03	2.47
Top Novelty	3.69	3.29	3.56	2.96
Median Novelty	3.11	2.74	3.05	2.49
First Use Novelty	3.00	2.53	2.93	1.97
Last Use Novelty	3.27	2.97	3.14	2.78
Fluency	3.00	3.10	3.08	2.67
Flexibility	2.41	2.42	2.28	1.71

Table of Significance Tests

Variable	**Effect**	***F***	***df***	***p***
Average Novelty	Product	10.40	1, 374	.001
	Environment	54.64	1, 374	<.001
	Interaction	2.28	1, 374	.13
Top Novelty	Product	6.23	1, 374	.01
	Environment	29.11	1, 374	<.001
	Interaction	1.17	1, 374	.28
Median Novelty	Product	5.33	1, 374	.02
	Environment	47.56	1, 374	<.001
	Interaction	1.87	1, 374	.17

First Use Novelty	Product	18.82	1, 374	<.001
	Environment	103.23	1, 374	<.001
	Interaction	11.78	1, 374	<.001
Last Use Novelty	Product	3.07	1, 374	.08
	Environment	13.10	1, 374	<.001
	Interaction	0.14	1, 374	.71
Fluency	Product	0.93	1, 374	.34
	Environment	0.87	1, 374	.35
	Interaction	2.10	1, 374	.15
Flexibility	Product	11.36	1, 374	<.001
	Environment	5.74	1, 374	.02
	Interaction	5.64	1, 374	.02

Study 5

Table of Proportions of Traditional Uses

	Traditional Uses	Non-Traditional Uses
Broken	38%	62%
Functional	75%	25%

Table of Significance Tests

Variable	$\mathbf{M_{broken}}$	$\mathbf{M_{functional}}$	***t***	***df***	***p***
Average Novelty	2.67	1.83	7.65	269.17	<.001
Top Novelty	3.66	2.97	3.68	302.58	<.001
Median Novelty	2.59	1.59	8.40	263.91	<.001
First Use Novelty	2.33	1.45	7.15	246.19	<.001
Last Use Novelty	2.92	2.13	4.51	304.54	<.001
Fluency	3.25	3.63	-1.71	316.97	.08
Flexibility	3.42	3.32	0.68	310.1	.50

Appendix C – Pre-registrations

C.1 Study 3 Pre-registration

Broken Wagon 2x2 Study (#86504)

Created: 01/28/2022 07:23 PM (PT)

This is an anonymized copy (without author names) of the pre-registration. It was created by the author(s) to use during peer-review.

A non-anonymized version (containing author names) should be made available by the authors when the work it supports is made public.

1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

In a previous study, we found that responses to an unusual uses task for a wagon were more creative when the wagon was broken. Our hypothesis is that participants are more creative with broken products because they separate them into components during their creative ideation. We predict that responses to an unusual uses task for a wagon will be more creative (relative to a control) when the wagon is either broken (i.e., not functional) or disassembled.

3) Describe the key dependent variable(s) specifying how they will be measured.

The key dependent measure will be the average novelty score of each participant's set of listed uses. Novelty scores will be assigned by independent expert judges who will assign each use a score ranging from 1 (Not novel at all) to 7 (Extremely novel). Discrepancies will be resolved via discussion. Average novelty score will be calculated for each participant by dividing the sum of the participant's novelty scores by the number of uses the participant listed.

While average novelty is the key dependent measure for our study, we will also measure the highest novelty rating within each response set (top novelty score), the number of uses the participant generated (fluency), the number of categories that are represented within each response set (flexibility), average appropriateness, and top appropriateness. Measures for appropriateness will be calculated in the same manner as measures for novelty, with appropriateness being rated on a scale from 1 (Not appropriate at all) to 7 (Extremely appropriate).

4) How many and which conditions will participants be assigned to?

There will be four conditions, as the study will follow a 2 (broken vs. functional) X 2 (disassembled versus whole) factorial design. Each participant will be randomly assigned to view a picture of a wagon that possesses one of the four combinations of these factors.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

Our main hypothesis will be analyzed using two-way ANOVA, specifying functionality (broken vs. functional) and assembly (disassembled vs. whole) as independent variable and average novelty as the dependent variable.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

Participants must list at least one interpretable use in order to be analyzed. Data for participants that do not fit this criterion will not be included in analysis. Partial responses will not be included in analysis. Manipulation checks will be included in the study, but the data will be analyzed both with and without excluding data from participants who failed one or more of the manipulation checks.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

No need to justify decision, but be precise about exactly how the number will be determined. Our target sample size is 350 based on departmental resources.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We also be including a analytic vs holistic thinking scale, a functional fixedness scale, questions regarding preferred problem solving strategies, demographic measures, willingness to pay, and questions regarding whether the participant viewed the wagon as a whole or as a collection of component parts.

Available at https://aspredicted.org/G9G_M3P

C.2 Study 4 Pre-registration

Lawn Mower Study (#89190)

Created: 02/24/2022 05:56 PM (PT)

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1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

Our previous studies have demonstrated that participants generate more novel uses for broken products than functional ones. We think that this is the case because broken products preclude the generation of conventional product uses while promoting the generation of unconventional product uses (Stokes, 2007). If this is true, we hypothesize that a manipulation of the contextual environment in which the product is embedded which precludes the generation of conventional uses while promoting the generation of unconventional product uses will produce similar effects on novel use generation. Specifically, we expect that uses generated for a lawn mower in a desert environment will be more novel than uses generated for a lawn mower in a lush environment with a lawn. Because the underlying mechanism for both effects is thought to be the same, we expect that, relative to the uses generated for a functional lawn mower in a lush environment with a lawn, the uses generated in each of the other three conditions (functional-desert, broken-desert, broken-lawn) will be more novel (to an equivalent degree). We will also test a moderated mediation model specifying product functionality as the IV, environment as the moderator, decomposition of the lawn mower as the mediator, and average novelty of uses as the dependent variable.

3) Describe the key dependent variable(s) specifying how they will be measured.

The dependent variable will be the average novelty of the uses participants generate for a lawn mower. This variable will be calculated by creating a master list of all of the uses participants generate. Each of these uses will then be evaluated on a scale from 1 (not novel at all) to 7 (extremely novel) by a peer group of judges (several MTurk participants). The novelty ratings of each of these judges will be averaged together to calculate novelty ratings for each use. Novelty scores for each use will then be averaged across each response set, resulting in an average novelty score for each participant.

4) How many and which conditions will participants be assigned to?

This study follows a 2 (broken vs. functional) X 2 (lawn vs. no lawn) factorial design with four conditions.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

The primary hypothesis will be tested using a 2x2 ANOVA.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

We will include manipulation checks for both of the factors in our study. Results will be analyzed with and without participants that failed the manipulation check(s). Participants that do not list any interpretable uses for the lawn mower will be removed from the analysis, as their data cannot be interpreted meaningfully.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

Our target total sample size is 400 based on a rule of thumb of 100 participants per cell.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We will include several variables for exploratory purposes. These include a measure of participants' willingness to take products apart, preference for reductive vs holistic problem solving, whether they feel constrained against disassembling the lawn mower, the extent to which they thought of the lawn mower in terms of its parts, familiarity with lawn mowers, peer judge ratings of appropriateness of uses, and demographic variables.

Available at https://aspredicted.org/QZB_TLD

C.3 Study 5 Pre-registration

Broken Product - Constraint Transfer Study (#77282)

Created: 10/18/2021 11:52 AM (PT)

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1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

In previous research, we have found that people performing the unusual uses test on products that are broken (as opposed to functional) generate more original uses on average. This study is designed to test a constraint relaxation account, which is that people approach the unusual uses test with an implicit constraint specifying that the product at hand should not be taken apart. This account may help to explain why people generate more original uses for products that are broken, because people may relax this constraint for such products. If this is the case, constraints which are relaxed for one product should be relaxed for a subsequently tested product (Knoblich et al 1999). As such, our hypothesis is that participants that perform the unusual uses test for a broken wagon will generate more original responses for a subsequent unusual uses test for a functional pair of scissors.

3) Describe the key dependent variable(s) specifying how they will be measured.

The key dependent variables in our study are the average originality ratings of participants' responses to the unusual uses tests in our experiment. These ratings will be assigned by independent trained judges scoring the originality of each use generated by participants on a scale of 1 (not original at all) to 7 (extremely original) and resolving any discrepancies via discussion.

4) How many and which conditions will participants be assigned to?

There will be two conditions: the broken product condition and the functional product condition.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

The main effect for our study will be analyzed using an independent two-samples t-test. We will also fit our data to a process model following the path of condition --> constraint relaxation --> originality.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

In the case that participants fail to generate one or more uses for either unusual uses test, these participants' data will be excluded row-wise from our analysis because they cannot be meaningfully interpreted.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

The target sample size for this study is 350 based on departmental resources for a study session with undergraduate student participants.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We have included several items intended to measure subjective analogical transfer between the two unusual uses tasks. These items will be averaged together for exploratory analysis. We have also included two items to measure participants self-report of having a constraint against taking each product apart (one item for each product). These two items will be averaged together to form our constraint relaxation measure which will be used in our mediation analyses. We will have our trained judges evaluate whether or not each use generated by each participant necessitates decomposing the product into parts. This binary measure will be used to test a process model following the path of condition --> chunk decomposition --> originality. Finally, we will also test a parallel process model which integrates both the constraint relaxation mediator and the chunk decomposition mediator as parallel processes affecting the originality of responses.

Available at https://aspredicted.org/M3Z_WGF

C.4 Study 6 Pre-registration

Broken Product Disposal Study (#28266)

Created: 09/23/2019 11:38 AM (PT)

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1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

Engaging creatively with a broken product will reduce participant self-reported likelihood of throwing the product in the trash.

3) Describe the key dependent variable(s) specifying how they will be measured.

Likelihood of throwing the product in the trash

Likelihood of reusing the product

Likelihood of recycling the product

Likelihood of selling the product

Likelihood of re-purposing the product

4) How many and which conditions will participants be assigned to?

There will be four conditions:

1) Functional product; creative uses task

2) Functional product; no creative uses task

3) Broken product; creative uses task

4) Broken product; no creative uses task

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

Two-way ANOVA

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

Participants will be removed if they exhibit strong evidence of nonhuman responses (e.g., word salad, text that has been copied and pasted from a website)

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

400 participants will be used based on a rule of thumb of 100 participants per cell.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

Nothing else to pre-register.

Available at https://aspredicted.org/EFO_HVR

C.5 Study 7 Pre-registration

Broken Fan Recycling Study (#36204)

Created: 02/24/2020 01:16 PM (PT)

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1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

We have observed in a previous study that people are more likely to indicate that they would recycle a broken product if they engage in a novel usage listing task with the product. We suspect that the reason for this is because people are mentally breaking the broken product into parts. We predict that providing participants with a broken product and having them perform the novel uses task for that product will increase the likelihood of recycling that product. We also predict that this will be mediated by the propensity for participants to break the product into parts during the novel uses task.

3) Describe the key dependent variable(s) specifying how they will be measured.

All participants will be given a portable fan to evaluate. After the study session is over, participants will be instructed to "dispose of all research materials, including sample products, before exiting the lab." The key dependent variable is whether participants throw the portable fan in the trash or recycle it. If the plastic body of the fan is placed in a recycling bin, this will be coded as recycling. If the plastic body of the fan is placed in the trash can, this will be coded as throwing the product in the trash. We will also observe whether participants break the fan into parts or not, and this will serve as a key mediating variable.

4) How many and which conditions will participants be assigned to?

This study will use a 2 (broken vs functional) X 2 (usage listing vs control) factorial design. Half of the portable fans have been rigged to not function and have had half of one fan blade cut off, while the others are fully functioning. Half of participants will perform the novel uses task, in which they are asked to generate as many uses for the fan as they are able. The other half of participants will simply be asked to write a description of the product.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

We will use a two-way ANOVA and subsequent post hoc comparisons. Mediation will be tested using Hayes' Model 4, with condition as the explanatory variable, breaking the product into parts as the mediating variable, and recycling as the outcome variable (Hayes, 2013).

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

Participants that do not dispose of the portable fan (e.g., leaving it at the desk, taking it with them) will be treated as missing data.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

Our target sample size is 400, based on departmental resources.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We will measure the extent to which the product is correctly recycled, whether it is recycled in part or in full, miscellaneous demographic and personality variables, and a battery of exploratory questions regarding the participants' opinions of the portable fan.

Available at https://aspredicted.org/KWX_F2J