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PROBLEM-SOLVING: INDIVIDUAL FACTORS PREDICTIVE OF RESISTANCE TO  
FUNCTIONAL FIXEDNESS AND EFFECTS OF EINSTELLUNG

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## ABSTRACT

The purpose of this research was to replicate and expand two experimental procedures that have been fundamental to the understanding of problem solving and rigidity: functional fixedness and effects of *Einstellung*. Functional fixedness can be described as an instance in which negative transfer occurs and there is perceptual “blindness” to the versatility of an object. *Einstellung* is the tendency to utilize a more complicated and habitually primed procedure at the expense of simpler methods. Results were analyzed to identify individuals resistant to these natural effects and to determine the non-clinical personality factors as assessed by the Myers-Briggs Type Indicator (MBTI, Myers, McCaulley, Quenk, & Hammer, 1998) that contribute to rigidity and fixation. A majority of participants (60%) responded in the same manner to the cognitive fixation problems (either susceptible or resistant to both functional fixedness and effects of *Einstellung*), indicating a salient connection between the cognitive mechanisms activated by these two phenomena. A significant relationship was discovered between susceptibility to cognitive fixation and the Thinking/Feeling dimension on the MBTI.

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## CHAPTER 1

## INTRODUCTION

Two major phenomena in problem-solving literature are the focus of this study: functional fixedness and effects of *Einstellung*. Functional fixedness can be defined as the tendency to view an object as serving only its conventional function rather than being versatile, capable of serving multiple functions. An effect of *Einstellung* occurs when an individual utilizes a cognitively programmed method for solving problems at the expense of contextually related, more efficient methods. These two phenomena are thought to be byproducts of the same cognitive process. The purpose of this study is to identify the relationships that exist between personality type and these particular problem-solving approaches.

The phenomena of functional fixedness and *Einstellung* have both been clearly demonstrated by many researchers. Functional fixedness and *Einstellung*, or mental set effects, have been used in research by experimenters operating from both Gestalt (Luchins, 1942; Maier, 1931) and cognitive theoretical perspectives (Gick & Holyoak, 1980). Although Maier (1931) was the first to demonstrate functional fixedness experimentally with his *string problem*, Duncker (1945) was the first to coin the phrase in his collection of experimental procedures called *On Problem Solving*. Duncker demonstrated similar fixation effects to those of Maier with the *candle-box* procedure as well as with a number of other tasks devised to illuminate the influence of problem presentation and contextual problem design on fixation. During the 1950s and 1960s, researchers focused on the concepts of rigidity and productive thinking, which are primary Gestalt assumptions about the manner in which individuals solve novel problems

(Luchins & Luchins, 1994; Woodworth & Schlosberg, 1954). The problem-solving literature was expanded in the 1980s with research on analogical problem-solving methods (Gick & Holyoak, 1980, 1983). Gick and Holyoak (1983) utilized procedures first developed by Duncker in their designs. Though interpreting the data from a cognitive perspective rather than through a Gestalt lens, they were able to use problems that induced functional fixedness with similar success to that of Duncker.

During the time that both Maier (1931) and Duncker (1945) were assessing functional fixedness phenomena, Luchins (1942) was demonstrating what he referred to as effects of *Einstellung*. All three of these aforementioned researchers were students of Michael Wertheimer (Luchins & Luchins, 1994), and all were respectively influenced insofar as the focus of their attention gravitated towards problem-solving processes. *Einstellung* can be generally described as the habituation to procedural problem-solving methods at the expense of simpler and more direct solution sets. Luchins (1942) was able to demonstrate this phenomenon with his now famous *water jar* tasks and other arithmetic problem sets. Luchins' *water jar* procedures have been used in social psychological research to demonstrate conformity, contextual rigidity, and personality factors that may affect problem presentation (Jackson, Messick, & Solley, 1957; Maher, 1957). There is significant support for the idea that rigidity, as exhibited in *Einstellung* situations, is a factor of both individual personality and situational factors (Belmont & Birch, 1960). Luchins and Luchins (1991) again demonstrated effects of *Einstellung* using traditional *water jar* problems and the *Tower of Hanoi* problem design utilizing a computer format. They later reviewed the history of *Einstellung* and its influence on the study of problem solving to summarize the research outcomes.

The original methods used to demonstrate these effects have been retooled yet remain seminal examples of experimental problem-solving procedure. Adamson (1952) repeated three of Duncker's original experiments and reported similar results to those of Duncker. Birch and Rabinowitz (1951) repeated Maier's string experiments, demonstrating that any of a number of objects could be primed for fixedness. Gick and Holyoak (1980) have used many of Duncker's original functional fixedness problems with great success in their analysis of analogical-type problem solving.

The phenomena of functional fixedness and *Einstellung* have been conceptually and experimentally linked throughout the literature; however, there has been argument as to whether these phenomena are examples of the same cognitive process or if they are manifestations of two completely separate problem-solving procedures (Kearsley, 1975). Adamson and Taylor (1954) found evidence that those individuals who were susceptible to functional fixedness were not necessarily more inclined to suffer from set fixedness, but they were more likely to have difficulty overcoming its effects once it had been established. In all instances in which these phenomena have been demonstrated, a few individuals have stood out who have not been susceptible to fixation effects, either when exposed to *Einstellung* problems or functional fixedness problem designs. There is research to indicate that these fixation effects may be contextually dependent and can be influenced by specific directions as well as experimenter behavior (external influences). Individual personality factors, knowledge base, and experience may also be responsible for these effects (internal factors; Luchins & Luchins, 1994; Maher, 1957).

Ramaprasad and Mitroff (1984) suggested that problem representation, how one views a problem, is influenced by personality type. They believed that an individual's perspective on the

world around him or her can be interpreted through the lens of Jung's personality theory (Ramaprasad & Mitroff, 1984). The way people perceive problem sets and interpret potential solutions based upon previous experience may have as much to do with personality traits as it does with situational factors. Reiter-Palmon, Mumford, and Threlfall (1998) speculated that personality factors are responsible for problem construction as well as originality of thought when solving novel problems. Jung's theory, as represented by the Myers-Briggs Type Indicator (Myers, McCaulley, Quenk, & Hammer, 1998), categorizes individual attention to the environment according to four dimensions. These are Judging/Perceiving, Sensing/Intuiting, Thinking/Feeling, and Extraversion/Introversion. Judging and Perceiving are terms that refer to the manner in which individuals interact with his or her environments. An individual who shows a preference for Judging may rely on past experiences and habits to make quick decisions about current situations. Those who show a high preference for Perceiving are more likely to conceptualize problem situations independent of experience, focusing on present-tense contextual factors (Myers et al., 1998). Originally, Jung posited four functions: sensation, intuition, thinking, and feeling. He theorized that these functions, both rational and irrational, were moderators of conscious interaction. Jung's extraversion and introversion refer to the manners with which an individual interacts with one's environment (Spoto, 1989).

Luchins (1942) theorized that those who are resistant to fixation effects rely on present experience and phenomenological interpretations of the context as primary supports for decision-making in problem situations, a description reflective of *perceivers* according to the MBTI (Myers et al., 1998). It is therefore possible that those who show a preference for Perceiving on the Myers-Briggs will be less likely to become fixated during Einstellung designs for this very reason. It is also possible that the same individuals will show resistance to functional fixedness

if Einstellung and functional fixedness are, in fact, part of a larger cognitive problem-solving framework. One can speculate that, in general, those individuals who exhibit similar typology according to the Myers-Briggs will yield similar results on the problem-solving designs.

Susceptibility to the effects of Einstellung is affected by the extent of rigidity demonstrated in one's personality structure (Jackson et al., 1957). Brown (1953) reported that rigidity is defined as the inability to restructure a problem situation in order to develop an appropriate and effective solution set. Carnevale and Probst (1998) found that those with rigid personality types were more likely to suffer from effects of cognitive fixation in problem-solving scenarios when they felt pressured by the researchers. It appears that context and personality type interact and affect problem-solving success.

Luchins (1942) devoted an entire chapter to those who are seemingly resistant to fixation in his treatise *Mechanization in Problem Solving: The Effect of Einstellung*. He reported that some individuals "refused to become conditioned" and that "their attitude basically was one of directly looking at the problem at hand in order to discover the proper way of solving it" (Luchins, 1942, p. 33). Other researchers have demonstrated that personality style and defensiveness are to blame for the strength of effect and susceptibility to fixation (Jackson et al., 1957; Maher, 1957). Belmont and Birch (1960) concluded that those who were determined as "better adjusted" according to Rorschach profiles tend to be more successful when presented with problems meant to induce Einstellung.

The present research is designed to confirm whether individuals who are susceptible or resistant to Einstellung effects are also susceptible or resistant to functional fixedness. This study will also identify whether certain personality characteristics such as Introversion, Extraversion, Sensing, Intuiting, Thinking, Feeling, Judging, and Perceiving are predictive of

susceptibility to fixation. Though prior researchers have speculated about the personality factors affecting problem-solving ability, quantitative tools used to assess non-clinical personality preference have not been used within the context of these problem-solving designs. Speculations were founded within the context of rigidity and have not, as of yet, focused more broadly on non-clinical personality profiles. The intent of the present research is to confirm whether or not a current assessment of non-clinical personality style, The Myers-Briggs Type Indicator (Myers et al., 1998), yields profiles that are predictive of resistance to and susceptibility for fixation effects in both functional fixedness and Einstellung procedures.

This study perhaps has most obvious application within the field of cognitive science. However, there is also the potential that the results of this study revealed data valuable in clinical settings. At the heart of the counseling relationship is understanding. It is essential that the counselor understands with relative accuracy the thoughts, feelings, and behaviors of his or her clients. In the active stages of counseling, problem solving is a valuable and often difficult task. In order to guide and assist a client, the counselor must understand how the client solves problems—in essence, the way one interacts with the world at large.

The MBTI has broad applicability in both clinical and non-clinical settings. It has been used to help individuals understand themselves and to assist the helpers to understand their clients. If a salient and reliable connection can be found between personality type, as assessed by the MBTI, and common problem-solving mishaps like cognitive fixation, then the counselor will have data valuable for use during the intervention stages of counseling. To illustrate, many come to counseling to address social conflicts. It is not uncommon for individuals to be aware that they have problems getting along with others, but to be unaware exactly why they have these social problems. It is often difficult for one to articulate a problem without awareness of the

source of the problem. As the results of this research suggest that there is a connection between personality type and a common problem-solving difficulty the counselor would do well to administer the MBTI during the process of therapy. With the knowledge that this research has provided, a counselor can then appropriately and effectively intervene as he or she will have sufficient data to make evidence-based clinical decisions regarding a client's problematic social interactions.

It was possible that four distinct groups would be found: those resistant to fixation effects in both the Einstellung and the functional fixedness procedures, those resistant to only one of these effects, Einstellung or functional fixedness, and those who are susceptible to both fixation effects. Another possibility was that only two groups would be identified. In the latter case, the two groups identified would be those who are susceptible to both fixation effects and those who are not susceptible to either.

Three specific research questions were addressed:

1. Do those who are susceptible to functional fixedness also suffer from effects of Einstellung?
2. Are there statistical differences between the average preference scores obtained for each dimension of the MBTI based on level of fixedness? For this analysis, level of fixedness was based upon susceptibility to both functional fixedness and effects of Einstellung, susceptibility to functional fixedness but not to the effects of Einstellung; susceptibility to Einstellung, but not to effects of functional fixedness; and resistance to both functional fixedness and to Einstellung.
3. Can group membership, as defined by level of fixedness, based upon susceptibility to both functional fixedness and Einstellung effects, susceptibility to functional

fixedness but not to the effects of Einstellung, susceptibility to Einstellung, but not to effects of functional fixedness; and resistance to both functional fixedness and to effects of Einstellung be predicted by the obtained personality factors from the MBTI?

## CHAPTER 2

### LITERATURE REVIEW

#### **Functional Fixedness**

Chronologically, Maier (1930) was the first to introduce problem sets that demonstrated the functional fixedness phenomenon. His purpose was to investigate reasoning processes in humans, following earlier problem-solving research by other Gestalt theorists who used animal participants. Perhaps the most famous of these examples comes from Wolfgang Köhler, whose chimpanzees were able to fashion sticks together to obtain food successfully that was initially out of their reach. This process is referred to as means-ends analysis type problem solving (Köhler, 1949).

Maier (1931) demonstrated with his student participants that when two strings were hung at a distance too far apart for a person to reach one string while holding the other, the simple machine principle of the pendulum must be utilized if one is to tie the end of string A to string B, or vice versa. A conventional tool, in this case a pair of pliers, must be perceived as a weight to tie to the end of the string rather than merely as a pair of pliers in order to solve the problem. Although alternative solutions were possible, the aforementioned solution was, in Maier's mind, the most creative of the options and the only one that demonstrated an understanding of the versatility of the tools at hand. Maier used this *string problem* as well as other problem-solving procedures to demonstrate that when an object is perceived as serving a conventional function, it is more difficult, and at times impossible, for a participant to see the object as serving any other more versatile or novel function. Maier's hypothesis was that individuals in the study were so

influenced by the previous knowledge of the function served by the object that they were unable to see the novel purpose the object served to solve the problem at hand. Pre-determined mindset prevented the participants from becoming aware of context-dependent organizing principles.

Maier's (1931) methodological rigor is decidedly questionable as he used a student population assigned to groups as he saw fit. As Maier reported, those participants who were deemed to be more intelligent than others (based upon previous interaction with the researchers) were purposely directed into specific groups. Maier (1945) nonetheless demonstrated that previous experience was not sufficient to solve novel problems and in some cases could be a hindrance. This was referred to as *negative transfer* and will be discussed later in this review.

Maier (1945), in the final part of his three-part project on human reasoning, defined the terms *productive* and *reproductive* thinking. He referred to *reproductive* thinking as “equivalence reactions [that] are adequate for solving some problems” (Maier, 1945, p. 350). On the other hand, *productive* thinking occurred when a person was able to obtain solutions to novel problems based upon more abstract reasoning processes, not simply from previous knowledge and experienced patterns. This concept had its foundation in Gestalt theory regarding perseveration and transfer (Luchins & Luchins, 1994).

Duncker (1945), a contemporary of both Maier and Luchins, was credited with coining the phrase “functional fixedness” in his collection of research designs entitled *On Problem Solving*. Duncker first referred to this theoretical construct in earlier work co-written by animal researcher Krechevsky, titled *On Solution Achievement* (Duncker & Krechevsky, 1939). Duncker and Krechevsky (1939) initially theorized that solution achievement must develop from a process of means-ends analysis. Both animals and humans must first be able to discover the

nature of the general range in which a solution might be obtained and then develop a functional solution within that context. This holds true for base animals as well as for humans.

A problem-solving monograph by Duncker (1945) referred to the *radiation* problem he set forth in earlier work (Duncker & Krechevsky, 1939) and introduced the *candle-box* problem. The radiation problem is one where a tumor must be exterminated in a person's body by the use of radiation. However, full powered radiation through the midsection would destroy both the healthy and the targeted tissue. The problem solver must devise a way in which one can irradiate the tumor, while at the same time refrain from destroying the healthy surrounding tissue. This problem has been commonly used in analogical problem-solving demonstrations (Gick & Holyoak, 1980). With the candle-box problem, participants are introduced to some simple materials on a table. Some of these items are useful in the problem-solving design and some are merely distractions. Participants are asked to devise a way in which they can affix the candles to a wall, using only the tools at hand. Duncker (1945) was able to demonstrate that when a box was used as a container to hold tacks, it was more difficult for participants to obtain a solution. However, when the tacks were separate from the box, participants more readily perceived the box as being able to serve the purpose of a platform from which to stand the candle and not simply as a container (Duncker, 1945). These problems and others have been used with various design alterations by problem-solving researchers to demonstrate functional fixedness as well as analogical solution transfer (Adamson, 1952; Birch & Rabinowitz, 1951; Carnevale & Probst, 1998; Chrysikou & Weisberg, 2005; German & Barrett, 2005; Glucksberg & Weisberg, 1966; Gick & Holyoak, 1980; Helfenstein & Saariluoma, 2006; Wedman, Wedman, & Folger, 1996).

Three of Duncker's original problem sets utilized to demonstrate functional fixedness phenomena were repeated with similar success (Adamson, 1952). Adamson (1952) used a larger

participant pool and more clearly designated experimental conditions to confirm that functional fixedness frequently occurred when participants were primed by the experimental design. Pre-utilization cognitively fixes an object. The newly cognitively fixed object influenced the participant's ability to solve the problem in a timely manner as the participant was less likely to see the object in a flexible manner. These results confirmed Duncker's earlier conclusions and solidified the concept of functional fixedness in research and problem-solving literature as a consistently demonstrable phenomenon. Adamson and Taylor (1954), in a follow up experiment, were able to find evidence that those susceptible to functional fixedness had more difficulty overcoming set effects.

Birch and Rabinowitz (1951) used Maier's string problem again in a later study. In this case, they actively primed functional fixedness prior to the introduction of the experimental problems. Either an electrical relay or an electrical switch was primed for conventional use prior to introducing participants to the problem set. Participants who were primed to perceive the switch utilized in its conventional way were more likely to use the relay as the pendulum weight. Those who were primed with the relay were more likely to use the switch as a weight. Those participants who were not primed for either were equally as likely to use the switch or the relay in their solution. This experiment demonstrated that immediately primed, context-dependent factors influence the demonstration of functional fixedness.

Yonge (1966) theorized and found support for order effects with functional fixedness priming. He found that when an item was first presented in a conventional way, that the participant was more likely to be susceptible to functional fixedness. However, when an item was presented and described as serving more non-conventional uses first, the participant was much less likely to become susceptible to functional fixedness. Yonge explained that when a

novel function is demonstrated prior to a conventional function, the participant's interpretation of that object remained relatively open; whereas when the conventional function is shown prior to more novel functions, the participant interpreted that object through a cognitively fixed lens, making it much more difficult to see the object as serving any other purpose.

Glucksberg (1962) conceptualized problem solving and functional fixedness in terms of the suppression-repression (S-R) drive theory. Although the results for the problem-solving task were not significant, Glucksberg was able to show evidence that when a common response was correct, external motivation enhanced perceptual recognition of the object needed. However, when the correct response was not the common one, motivation impaired performance on the perceptual recognition task. In other words, social pressure inhibited performance for creative solution attainment. It was more likely in this case that an individual would perceive the common response first and less likely that an individual would perceive a novel use for a fixed object. Carnevale and Probst (1998) found that those who expected social conflict while solving Duncker's candle-box problem suffered from "a freezing of cognitive schemas" (p. 1307) and were less likely to come up with the creative solution. The opposite was true for those who expected cooperation.

Labeling can also have an effect on functional fixedness. Within the context of Duncker's candle-box problem, Glucksberg and Weisberg (1966) labeled the available items in such a way as to either prevent or encourage functional fixedness. When the box was labeled as merely a *box*, the solution was more readily available to the problem solver. When it was labeled as a more specific *tack box*, the solution became more elusive. The researchers theorized that the findings "suggest that it is not a function that is unavailable to S [subject], but rather the functionally fixed object itself" (Glucksberg & Weisberg, 1966, p. 659). In other words, the

participants did not even perceive the object as being available until attention was drawn to the object by the correct label. This finding suggests that interpretation of available tools, not simply perception of tools, was essential for effective problem solving to be accomplished.

The functional fixedness phenomenon has been demonstrated with other tasks as well. German and Barrett (2005) demonstrated that individuals from a culture with few conventional and commercial tools were just as likely to suffer from fixation effects when tools were primed to a certain function ahead of time. Functional fixedness is often demonstrated using concrete examples and manipulatives, but can also be demonstrated when different modes of presentation are used. Participants were more likely to utilize picture examples than they were written instructions when solving problems, even when the examples contained incorrect elements (Chrysikou & Weisberg, 2005). These fixation effects, however, were diminished when the experimenters gave specific limitations in their directions to the participants, and instructed them not to utilize procedures set forth in prior examples when developing novel problem solutions.

### **Effects of Einstellung**

Luchins (1942), in his monograph titled *Mechanization in Problem Solving: The Effect of Einstellung*, demonstrated that participants were blind to a simple solution when the previous tasks presented required them to utilize a more complex procedure. Utilizing the water jar tasks, he showed that “the successive, repetitious use of the same method mechanized many of the participants—blinded them to the possibility of a more direct and simple procedure” (Luchins, 1942, p. 1). He referred to this phenomenon as *Einstellung*. He reported that the blindness participants experienced was due to the context of the problem situation and the procedure rather than being a fundamental human characteristic of problem-solving conceptualization. Luchins hypothesized that some individuals were resistant to *Einstellung* due to the attitude that they

brought to the problem situation. They were able to assess the problem directly and solve it more efficiently, rather than relying on a previously utilized successful procedure.

Luchins' water jar tasks have been re-worked to be solvable by multiple different procedures, both with concrete methods and theoretical constructs. A basic example is provided that will assist in the understanding of this concept. If a participant is provided with three water jars of differing size, and then asked to fill one of those jars to a specific volume (a volume not directly available by filling only one of the jars), he or she might be provided with a complex procedure that will result in a successful solution. For example, the solution might require the algebraic procedure  $B-A-2C$ , where A, B, and C are integers. This example comes directly from one of Luchins's experimental procedures (Luchins, 1942, p. 2). If the participant is then presented with multiple consecutive tasks requiring this solution procedure, he or she becomes fixated on its usage. In the experimental phase, the participant is introduced to a similar problem that can be solved by utilizing a simpler ( $A-C$  or  $A+C$ ) method. In this case they are unable to see the easier and more efficient solution due to fixation on the previously successful, though more complicated, procedures. He or she become rigidly habituated in their response to the problems that confront them.

Ollinger, Jones, and Knoblich (2008) referred to this phenomenon as *mental set* rather than *Einstellung*. They advocated for the representational change theory (RCT) in problem solving. This theory essentially states that problem solving requires a certain level of insight that comes from the mental representation that one has of that problem. In other words, insight requires effective interpretation of the problem at hand in order for one to choose and utilize an effective procedure.

There are also order effects that have been shown in regards to Einstellung. Luchins and Luchins (1991) found that task complexity and order affected problem solving. When simpler problems were presented first, the solutions to subsequent problems were more efficient and more readily perceived. When the order of the problems presented was such that more difficult solutions preceded simpler ones, the more traditional effects of Einstellung were demonstrated. Einstellung, in this case, may be influenced by the ways in which participants conceptualize and learn overall, rather than just an effect due to repeated behavioral indoctrination or perseveration.

Functional fixedness and Einstellung were originally conceptualized within the same framework, and were thought to be the same phenomenologically (Adamson & Taylor, 1954; Kearsley, 1975). However, the contextual dependency model proposed by Kearsley (1975) indicated that these two phenomena may be rather separate products of underlying structures within an overarching cognitive framework. In other words, they are related but distinct results of problem presentation and perception. Functional fixedness and Einstellung both require a context-dependent and a context-independent process, but these are reversed in the two fixation effects (Kearsley, 1975). When a tool is utilized in a context-independent manner, functional fixation can occur if the participant cannot perceive and interpret the tool as serving context-dependent function. When a context-dependent procedure is utilized over and over again, as with an Einstellung inducing procedure, the solution process becomes context-independent and is transferred to following problem situations. Functional fixedness appears to be an unconscious fixation, where individuals who suffer from the effects often fail to report awareness of such fixation (Duncker, 1945). However, those who have been susceptible to effects of Einstellung have often reported a consciousness of their own fixation on a certain method (Kearsley, 1975). Kearsley (1975) spoke of this within the context of positive and negative transfer.

Positive and negative transfer in problem solving refer to the aforementioned *productive* and *reproductive* thinking introduced by Maier (1945). Negative transfer is evidenced by the phenomena of both functional fixedness and Einstellung such that previously learned knowledge and procedure prevent solution transfer from occurring by context-dependent means (Kearsley, 1975). Positive transfer can be demonstrated by the successful use of analogy to solve similar and yet distinct problem sets (Chrysikou & Weisberg, 2005).

Positive transfer is a product of apperception, or “the process of constructing mental representations” (Helfenstein & Saariluoma, 2006, p. 293), useful for the current problem situation and based upon previously learned stimuli. Essentially, a level of interpretation is necessary if one is to understand completely the problem at hand, even when an appropriate analogy can be derived from previous experience. Problem solving is not merely a process of eliminating possible solutions, but rather it requires that the problem presented be perceived through the lens of meaning and personal significance.

In order for an analogous problem to transfer positively to a novel problem set, the priming analogues must be highly related and repeated multiple times. Activation of a general cognitive schema, in this case, is insufficient (Gick & Holyoak, 1983). Successful problem solvers are those who are able to think efficiently about the problem at hand, who then demonstrate the use of a predictable approach to problem solving, and who are able to draw appropriate analogies from life circumstance and experience to weigh on the current problem set (Wedman, et al., 1996). An order effect also takes place in analogous problem solving; those who are taught principle-based methods to problem solving take more time with initial problems but then are able to more effectively and efficiently solve subsequent ones. This is the reverse for those who are taught to utilize procedure-laden methods in problem solving. This trend

seems to indicate that those who are taught to conceptualize problems based upon the principles needed to solve all problems, rather than a simple method for solving a specific problem, take more time to understand and assess the problem context initially but are better able to transfer knowledge and learning to novel situations later on (Wedman et al., 1996).

Egan and Greeno (1973) supported this claim in their assessment of the differences between learning by discovery and learning by rule. They concluded that learning by rule leads to the addition of a new method for problem solving. However, learning by discovery leads to integration and re-interpretation of previously learned knowledge in such a way that new schemas were constructed by the learner. In the latter example, an individual may more readily confront novel situations based upon his or her learning and understanding of underlying principles. Conversely, the individual who learns by rule is constrained to a specific method and is unable to tackle a novel problem without first re-interpreting and making meaning of previous learning experiences, a procedure which the discovery-based learner has already integrated into his or her personal schema.

For analogous transfer to be successful, provided analogues must have a proximate relationship to the following novel problem. In other words, the use of an analogy requires previous experience with a closely related problem. However, analogy can transfer across domains if the problem solver is able to interpret accurately and meaningfully the presented problems. Those who are able to infer underlying principles rather than simply perceiving the face value of an analogue are more readily able to utilize their understanding to solve novel yet disparate problems (Gick & Holyoak, 1980).

Evidence indicates that external factors can influence problem-solving ability and transfer. Carnevale and Probst (1998) reported that when participants were taught to expect

either conflict or cooperation, their ability to solve a Duncker-type candle-box problem was affected. Those who were taught to expect cooperative efforts on the part of the experimenter categorized objects fluidly and were more inclusive in their descriptions of the items at hand, thus deriving correct and creative solutions in an efficient manner. Those who were taught to expect conflict were much more rigid in their representations and had a higher level of difficulty in solving the problem at hand. Personality style affects how we respond in social contexts; therefore context-dependent factors may be more or less robust when personality style and social preference are taken into consideration (Belmont & Birch, 1960).

### **Personality Factors in Problem Solving**

It has been reported that problem construction and representation play a role in how an individual is able to develop solutions in novel situations as well as with analogous problem sets. Reiter-Palmon et al. (1998) were able to demonstrate that originality and creativity in solving everyday problems was as much related to personality as it was to problem construction. Participants in this design who were able to develop creative solutions to presented problems did so in ways that were consistent with their personality types. When a solution was determined and interpreted in a way that was congruent with the individual's personality, solutions were said to be of higher quality and were more appropriate for the presented problem.

In a conceptual piece, rather than an experimental design, Ramaprasad and Mitroff (1984) speculated that the perception and judgments based upon Jung's personality typology could account for problem formulation and interpretation. Jung's typology, according to the authors, can be related to Piaget's model of processing in that perceiving is synonymous with simple abstraction and judging is synonymous with reflexive abstraction. Simple abstraction has

to do with problem representation, whereas reflexive abstraction has to do with interpretations derived from post hoc experience.

Former research on personality type and conventional rigidity indicated that rigidity is influenced by contextual as well as individual factors. Rigidity occurs when an individual has difficulty solving a problem efficiently due to the inability to restructure the perceived field in which the problem is presented (Rokeach, 1948). It has been shown that an individual characterized as having an authoritarian personality, when presented with an arithmetic problem in a relaxed social environment, was able to solve novel problems more readily and successfully. However, if the authoritarian type was presented with the same problems in a hostile and confronting manner, effects of *Einstellung* were engaged more strongly in this person and increased rigidity occurred (Brown, 1953). In some sense, a rigid individual in a problem-solving situation may be more likely to cling to previously successful solution methods, rather than evaluating problems based upon contextually dependent factors. These findings support those by Carnevale and Probst (1998), whereby those who expected conflict demonstrated increased rigidity in problem-solving presentation.

Maher (1957) also speculated that rigidity in problem-solving situations might be a product of dependent situational factors. He posited that those who feel threatened are more likely to experience problem-solving rigidity, thus being more susceptible to effects of *Einstellung*. Some have even gone so far as to assert that the water jar problems used to demonstrate *Einstellung* can be a valid measure of testing one's level of willingness to conform and acquiesce (Jackson et al., 1957). Levitt and Zelen (1953) questioned the appropriateness of using *Einstellung* inducing tasks as measures of rigidity; however, they were unable to find significant results indicating that situational factors such as incentive impacted problem-solving

performance. Some factors that have been shown to contribute to one's susceptibility to rigidity on problem tasks have been age, gender, mental illness, and intelligence (Schultz & Searleman, 2002).

Throughout the problem-solving literature, there are examples of individuals who were seemingly unsusceptible to fixation effects. These people have emerged time and again, both within the context of functional fixedness and Einstellung designs. However, there were always those who did demonstrate rigidity and became fixated on both Einstellung and functional fixedness designs. These findings indicate that susceptibility to fixation is also a product of contextually independent factors such as personality and problem-solving ability rather than merely situational influences. One can therefore assume that there is an interaction between situational factors and independent factors influencing problem representation and solution attainment. It is possible that those who have difficulty solving functional fixedness problems will also suffer from effects of Einstellung.

Personality type is an idea first proposed in a comprehensive theory by Jung (1923). He speculated that one's orientation to the world was interpreted through an individual conscious preference for extraverted or introverted social energy, an unconscious perceiving preference for sensing or intuiting, as well as preference for judging functions such as thinking or feeling. Jung indicated that these preferences could be further distilled into two basic cognitive processing styles people employ when interpreting the surrounding environment. Myers et al. (1998) explicitly termed these cognitive processing styles, or orientations, Perceiving and Judging. Those with a preference towards Judging tend to prefer order, organization, and closure whereas those with a penchant for Perceiving tend to be flexible, adaptable, and present focused.

With Jung's theory in mind, Myers et al. (1998) developed an assessment protocol, the MBTI, in order to utilize Jung's theory in practical and standardized practice. This instrument is widely accepted by psychological professionals as a tool used to assess personality and psychological type. Myers et al. cited numerous studies indicating that the instrument is both valid and reliable as a standardized measure.

There is also evidence that indicates that these personality types may be more accurately conceptualized as independent entities rather than the opposing forces that they are presented as within the context of the MBTI (McCrae & Costa, 1989; Ramaprasad & Mitroff, 1984). Within the context of this design, personality type was assessed as independently functioning entities rather than dichotomous and exclusive of one another. There are opponents of the instrument who argue whether or not the MBTI, as an assessment, is congruent with Jung's original theory (Loomis, 1982; Spoto, 1989). Proponents of the Singer-Loomis Inventory of Personality (SLIP, Loomis, 1982) question the bipolarity of Jung's personality constructs because there has been little empirical evidence to support the claim. It is understood that, though there is some incongruence between the MBTI and Jung's original typology, the instrument itself is widely utilized in applied settings as a functional assessment of non-clinical personality preference (MacDonald & Holland, 1993).

As the MBTI was developed as a positivistic measure, one in which no type is better or worse than another, it is possible that those most likely to solve problems in the creative fashion will be those who do not predominantly operate in one fashion or another. In other words, those who do not have a strong preference for one type or another, but are able to perceive and judge their surroundings and problems situations in myriad ways, will be most likely to develop creative solutions successfully as defined by both the functional fixedness and Einstellung design

procedures. As mentioned, however, the scoring is reported on the MBTI as dichotomous where the extraverted type is conceptualized as being the opposing force to the introverted type and so on throughout the entire personality profile. As referenced earlier, McCrae and Costa (1989) believed that it was perhaps more accurate to interpret all types as distinct entities rather than polar opposites and interacting variables. Therefore, it is possible that those who have a high preference for one type or another as indicated by the MBTI will be more likely to become fixated when performing functional fixedness and Einstellung tasks. Those who show a more balanced profile would seem more predisposed to experience what Maier (1931) referred to as the “‘transformation’ or ‘organization’ stage,” in which the “new organization is suddenly there” (p. 191). More integrated individuals would seemingly have a more balanced perspective and orientation, thus allowing them to utilize more perceptual tools.

Extraverted individuals tend to have a more objective attitude towards the world around them whereas introverted individuals are more participative (Myers et al., 1998). With regard to the irrational perceptive processes, Sensing types are oriented to currently occurring phenomena, whereas those who score high on measures of Intuition tend to be oriented by the potential or etiology of a recognized pattern. Rational thought processes are influenced by thinking or feeling patterns. Thinking individuals use systems and rules to make sense of their surroundings, and Feeling types tend to organize information based upon their participative experience of a thing (Jung, 1923). Perceivers, according to the MBTI profile page (Myers et al., 1998), are more likely to be flexible, spontaneous, and to keep options open rather than taking the perceived environment at face value and allowing themselves to become fixated on a certain procedural method. Judgers, on the other hand, are most likely to rely on post hoc experiences to come to quick conclusions (Ramaprasad & Mitroff, 1984), thus making them susceptible to effects of

Einstellung as well as functional fixedness. A more balanced profile might suggest that a combination of factors would intervene, allowing the participant to utilize multiple perspectives in order to formulate possible solutions.

This research assessed whether preference (Extraversion, Introversion; Sensing, Intuiting; Thinking, Feeling; Judging or Perceiving types and combinations thereof), as assessed by the MBTI, are predictive of resistance to or susceptibility for functional fixedness and Einstellung effects. It is hypothesized that there will be a percentage of people who, after being participated to both Einstellung problem sets and functional fixedness designs will emerge as unfixed in both arenas. These individuals are hypothesized to have similar personality structures that affect the ways in which they perceive and interpret novel problems, allowing them to develop solutions in an efficient and effective way rather than demonstrating susceptibility to rigidity and fixation.

For the purpose of clarity and review, the research questions being addressed by this study were

1. Do those who are susceptible to functional fixedness also suffer from effects of Einstellung?
2. Are there statistical differences between the average preference scores obtained for each dimension of the MBTI based on levels of fixation? For this analysis, levels of fixation will be based upon susceptibility to both functional fixedness and effects of Einstellung, susceptibility to functional fixedness but not to the effects of Einstellung, susceptibility to Einstellung, but not to effects of functional fixedness, and resistance to both functional fixedness and to Einstellung.
3. Can group membership, defined by levels of fixedness, based upon susceptibility to both functional fixedness and Einstellung effects, susceptibility to functional

fixedness but not to the effects of Einstellung, susceptibility to Einstellung, but not to effects of functional fixedness, and resistance to both functional fixedness and to effects of Einstellung be predicted by the obtained personality factors from the MBTI?

## CHAPTER 3

### METHOD

This research design has two steps and involves a personality assessment phase and a problem-solving phase. All participants were taken to a classroom-type setting where they were asked to complete the informed consent form and the assessment package to include the MBTI (Myers et al., 1998). Participants were then asked to complete two problem-solving activities: Duncker's (1945) candle-box problem and the Einstellung water jar problems (Luchins, 1942). The order of the activities was counterbalanced.

#### **Participants**

The original goal was to recruit 160 volunteers from a student population enrolled in undergraduate courses at a Midwestern university to participate in the design. The target number of 160 participants was based on the number necessary to meet the assumptions of originally selected statistical analyses. Of the eight classes recruited with a total student population of approximately 450, only 42 volunteers chose to participate. Of the 42 participants, 33 were female and 9 were male. In a total of four samples, the participants did not demonstrate effects of Einstellung, but gave mathematically incorrect answers to the experimental items. These samples were therefore not included in the final calculations. One sample was discarded due to an incomplete MBTI profile.

The principal investigator contacted teaching faculty to obtain permission to recruit students from available undergraduate courses. After obtaining permission, a research assistant attended a session of the class and presented an invitation to participate in the current study.

Volunteers then chose a date and time to participate based upon availability. There were 20 spaces available for each time slot.

Upon arrival to the testing site, participants were asked to read the consent form (see Appendix A) prior to participation. The research assistant explained the procedure for the design. After informed consent was obtained, participants were individually asked by a research assistant if they were familiar with Einstellung, the water jar problems, or the Duncker candle-box problem. If the participant said, “yes,” then the participant was directed to another assistant who asked them to explain what they knew about Einstellung, the water jar problem, or the Duncker candle-box problem. The research assistant then determined if the participant’s knowledge would interfere with his or her ability to participate. Specifically, if the participant knew the solution to the problems or the impact of fixedness with these problems, then the student was dismissed from the project. If the participant did not have the stated knowledge, but recognized the problems, he or she were asked to continue.

After screening, participants were randomly provided with a five-digit number with the last two digits being between 1 and 20. These numbers served to assign participants to experimental groups, using approximately 10 participants per group. All participants were then asked to complete the experimental procedures. Those who chose to leave at any point were removed from the design, incurring no penalty or defamation. All participants who arrived for testing sessions chose to participate fully in the project.

### **Procedures**

After providing consent and receiving their identification numbers, each group of participants was divided according to participant number into two groups. Once separated into two groups and after being led to respective testing sites, the participants were provided with the

MBTI and the demographics sheet (see Appendix B). Participants were asked to write their five-digit numbers on the MBTI and the demographics sheet. The demographics sheet was used to collect the following information: age, sex, race/ethnicity. Standardized directions for the MBTI were read to each group and participants were asked to complete the demographics sheet and the MBTI.

After all group members completed the MBTI, the groups proceeded to the problem-solving tasks. These tasks were administered by the aforementioned volunteer graduate student research assistants. Each assistant was trained to administer the MBTI and the problem-solving tasks by the lead researcher. The training consisted of instruction on the activity and then two mock administrations observed by the lead researcher and others highly knowledgeable about the problem-solving activities. Assistants were provided with the necessary materials prior to the experiment.

The participants in the functional fixedness group were asked to complete the functional fixedness (FF) problem first, followed by the Einstellung (E) problems. The research assistant administered the FF problem according to the procedure provided in Appendix C. Meanwhile, the participants in the Einstellung group were instructed by a research assistant to complete the E problems first, followed by the FF problem. This procedure is outlined in Appendix D. Upon completion of the second task, participants were thanked for their participation and asked not to speak of the activities with their peers until the end of the semester.

### **Materials**

For this research, participants completed the MBTI, an adapted paper format of the FF problem (see Appendix C) similar to the forms used by Glucksberg and Weisberg (1966), and E problems (see Appendix D). The MBTI (Form M, 2003) is a 93-item, self-report assessment that

has been found to have internal consistency reliability scores between .90 and .94 depending upon the type dichotomy tested and based on split-half correlations (Myers, McCaulley, Quenk, & Hammer, 2003). Scores of internal reliability were based on a coefficient alpha range between .91 and .92 according to national sample data (Myers et al., 2003). Form M has been demonstrated to be consistent over time. Reported changes in type preference are likely to occur in only one preference and usually when the prior preference was scored in the middle range of the dichotomy (Myers et al., 2003).

Researchers have suggested that there is strong evidence to support the idea that the items in the measure do, in fact, load on their intended type scales when an exploratory factor analysis is used (Tischler, 1994). A number of studies have yielded percentages between 53% and 85% regarding agreement between obtained personality preference-type and self-estimates of type. Researchers have found that more than 50 percent of people are likely to agree with their type description according to the MBTI (Myers et al., 2003). These percentages remain strong when independent raters are also used (2003). Myers et al. (2003) also suggested that the above data, along with correlational data comparing this instrument to other common measures of personality such as the 16 Personality Factors Questionnaire, the Millon Index of Personality Styles, the California Psychological Inventory, and the NEO-Personality Inventory, serve to further support the supposition that the MBTI is a valid instrument.

Participants were asked to devise a method for solving the problems in written format (Carnevale & Probst, 1998). The correct solution to the FF task was attained if the participant indicated that they would use the tacks to affix the box to the partition, in order that they can use it as a platform for the candle. The participant must also indicate that they would melt the candle bottom using the matches to affix the candles to the boxes (Adamson, 1952).

For the E problems, an E packet was provided that included Luchins's (1942) original water jar problems in an adapted format for the experiment. These problems are explained in the following segment by Adamson and Taylor (1954):

In each problem, the task is to explain how a stipulated quantity of water could be obtained by using jars of given sizes; e.g., given an empty 14-qt. jar, an empty 36-qt. jar, and an empty 8-qt. jar; measure 6 qt. water. Problem 1 involves only two jars and is given to illustrate the nature of the task. Problems 2 to 6 are all solved in the same way: first fill the second jar, then subtract from it the amount necessary to fill the first jar once and the third jar twice. Problems 7, 8, 10, and 11 can also be solved in this way or, more directly, in one step which does not involve the second jar. Problem 9 can be solved only by the more direct method. The time allowed for each problem was 1.5 min. (p. 124)

Susceptibility to fixedness was determined by the participant's selection of strategy used for problems 7 and 8. If the participant continued to use the same strategy used to solve problems 2 through 6, then the participant was determined to be susceptible to the Einstellung effect, or set fixedness. Problems 9 through 11 were used by Luchins (1931) to test extinguishing behavior related to effects of Einstellung and therefore were unnecessary for this design.

### **Design**

The current research followed a quasi-experimental design. This design is most appropriate when random assignment to groups is not feasible. The purpose of this research was to identify associated relationships between naturally occurring personality types and susceptibility to fixation. Neither of the variables was directly manipulated, thus assignment to

condition was not possible. The current research examined differences in personality type preference and susceptibility to fixation.

### **Analysis**

The research questions and the associated analysis were as follows:

Research Question 1. Do those who are susceptible to functional fixedness also suffer from effects of Einstellung?

This question was answered by cross tabulating the participants' susceptibility to functional fixedness with their susceptibility for the effects of Einstellung. As defined by Duncker (1945) the creative solution to the FF task is to affix the candles to the boxes by melting the bottom of the candles, then to attach the boxes to the partition using the available tacks. All other answers were considered incorrect. However, demonstration of functional fixedness was noted when the participant did not use the tack box as a platform for the candle. For the E problems, set was evidenced by use of the indirect method to solve problems 7 and 8, rather than a simpler method. Use of either method would result in a correct answer, but use of the simpler method on either of these problems was considered evidence of resistance to effects of Einstellung. These attempts were differentiated from one another in the analysis with the utilization of the indirect method being evidence of set fixedness for both problems 7 and 8.

Susceptibility to functional fixedness was indicated if a participant did not use the box as a platform for the candle when solving the FF problem. Susceptibility to the effect of Einstellung was indicated if a participant continued to use the complex strategy from problems 2-6 to solve both problems 7 and 8. The cross tabulation had the possibility of generating either two or four groups. If the two effects are highly related, it is possible those participants susceptible to one will be susceptible to the other, and those who are not susceptible to one will

not be susceptible to the other. This would have generated two groups and suggested that the effects are highly related. It was also possible that the results would generate four groups: (a) participants susceptible to both functional fixedness and effects of Einstellung, (b) participants susceptible to functional fixedness but not susceptible to effects of Einstellung, (c) participants susceptible to effects of Einstellung, but not susceptible to functional fixedness, (d) participants not susceptible to either functional fixedness or to effects of Einstellung.

A chi-square analysis was used to determine whether susceptibility to functional fixedness is independent of susceptibility to effects of Einstellung. An a priori power analysis was conducted to determine the appropriate sample size for this statistical calculation. In order to ensure a 95% chance that a statistical difference will be identified if there is one, approximately 145 participants would have been needed (Faul & Erdfelder, 1992). The grouping variable was susceptibility to Einstellung. An insignificant chi-square would indicate that being susceptible to Einstellung is independent of susceptibility to functional fixedness. The chi-square statistic has the following assumptions:

1. Observations must be independent. This assumption will be met as the two activities are independent of one another.
2. Any participant must fall into one and only one category. Susceptibility for both measures is dichotomous. Participants can only fall into one and only one category for either measure.
3. The computation must be based on all participants. All participants will be included in the cross tabulation.

4. With degrees of freedom of 1, there must be a minimum of 5 observations per cell.

Even if there are four groups, there will be at least five participants per group from which data are obtained (Mertler & Vannetta, 2005).

Research Question 2. Are there statistical differences between the average preference scores obtained for each dimension of the MBTI across levels of fixedness?

This analysis used the groups generated by the cross-tabulation used for Research Question 1 as the independent variable and the preference scores from the MBTI dimensions as the dependent variables. Thus, there is one independent variable and four dependent variables, one preference score for each individual on each of the four dimensions of the MBTI.

This question was to be answered by using multiple analysis of variance (MANOVA) with level of fixedness as defined by susceptibility to both the FF and the E problem sets as the independent variable. The following scores of the MBTI were collected; participant preference for type for each of the four dimensions: Introversion-Extraversion, Sensing-Intuiting, Thinking-Feeling, and Judging-Perceiving. The obtained preference score for the selected type on each dimension was the dependent variable. A significant MANOVA would have been followed by a one-way ANOVA with Tukey's LSD as the post hoc multiple t-test.

The MANOVA has the following assumptions (Mertler & Vannetta, 2005):

1. Observations in each sample must be randomly sampled and must be independent of one another. This assumption should not be violated as each participant can only be in one of the cells of the cross-tabulation performed for research question #1. The responses used for creating the categories are independent of one another as well.

2. The observations on all dependent variables must follow a multivariate normal distribution in each group. This assumption should not be violated, provided that there is a minimum of 20 individuals per cell.
3. The covariance matrices for the dependent variables must be equal. Analyses used to test homogeneity of covariance will be used to ensure homoscedasticity (e.g., examination of scatterplots generated from the data on the first two discriminant functions generated separately for each group).
4. The relationships among all pairs of dependent variables in each cell must be linear. Type, according to the MBTI, is scored linearly for all variables in the design (Mertler & Vannetta, 2005).

Research Question 3. Can group membership, defined by levels of fixedness, based upon susceptibility to both functional fixedness and effects of Einstellung, susceptibility to functional fixedness, but not to the effects of Einstellung, susceptibility to Einstellung, but not to functional fixedness, and can resistance to both functional fixedness and to effects of Einstellung be predicted by the obtained personality factors from the MBTI?

The following scores of the MBTI were collected for each of the four dimensions:

Introversion-Extraversion, Sensing-Intuiting, Thinking-Feeling, and Judging-Perceiving. For the analysis of the preference scores, the preference scores were coded in one of three ways. Data were first coded in such a manner as to obtain a total preference score (total items endorsed).

This took into account all of the items endorsed on a single dimension for each preference dimension. Then the total items endorsed were calculated as a continuous score for each dimension. For example, if on the Extraversion/Introversion dimension, an individual endorsed 15 items indicating an Extraversion preference, then that score was added to 100 giving a total

score of 115. Conversely, if the individual endorsed 15 items indicating an Introversion preference, then that score was subtracted from 100 giving a total continuous score of 85.

The second way of coding was to look at the difference between the scores for each dimension, identifying the direction and magnitude of the preference for each dimension. For example, if an individual endorsed 17 items indicating Extraversion preference out of a total of 21 items on that dimension he or she would have then endorsed four items indicating Introversion preference. The difference between these scores is 13. This score was then calculated as a continuous score. The continuous score in this case would be 113 as the direction of preference was towards Extraversion and was therefore added to 100. Had the direction of preference been towards Introversion, the difference score would have been subtracted from 100. This scoring, in effect, allows calculation of the difference and direction of preference for each dimension.

The third way of coding the data obtained from the MBTI was to use the simple difference between preference scores on each dimension, creating a scale that identifies how balanced an individual's personality preference is for each of the dimensions of the MBTI. In this instance, preference type is ignored and focus is on how balanced a personality preference is for each dimension. For example, if 15 items were endorsed for Introversion preference, and six items were endorsed indicating Extraversion, the difference score for that scale would be 9.

The three continuous scores were analyzed to determine if scores from the MBTI could predict levels of susceptibility to fixedness, based on the groups generated by the cross-tabulations described in Research Question 1. It was predicted that the above four groups would vary on the assessed personality variables. To test that the four groups could be identified based upon their preferences on the four dimensions of the MBTI, a discriminant analysis would have

been conducted with susceptibility to fixedness being the grouping variable and the continuous scores from the MBTI being the predictor variables.

With respect to these last two analyses, two metrics to determine appropriate sample size have been reported. It has been suggested that the ratio of the total sample size must be at least 20:1 as compared to the number of predictor variables (Mertler & Vannetta, 2005). In a case where there are four predictor variables, as with this design, a total of 80 participants would be needed to ensure normality. The second criterion is based on the number of participants in the smallest group. A sample size of approximately 20 participants in the smallest cell would have been sufficient to ensure that one can trust the robustness of the results obtained (Mertler & Vannetta, 2005). When one considers earlier research findings, one can expect approximately 13 percent of individuals tested to be resistant to effects of Einstellung (Luchins, 1931). On average, approximately 15 percent of individuals tested will be resistant to functional fixedness (Duncker, 1945). Therefore, using the 13 percent from the research on Einstellung, obtaining data from approximately 160 participants was the target for this design to ensure that the smallest cell, those resistant to effects of Einstellung, had approximately 20 individuals.

The discriminant analysis has the following assumptions:

1. Observations of the predictor variables must be randomly sampled and must be independent of one another. With respect to the MBTI scales, the scales are reported to measure independent constructs. Also, since the participants were volunteers, it would be likely that the final scores would be random.
2. The sampling distribution of any linear combination of predictors is normal. Provided there are approximately 20 individuals in the smallest cell, it would have been likely that this assumption was not violated.

3. The population covariance matrices for the predictor variables in each group must be equal. Analyses checking for univariate and multivariate normality would have been conducted. To test this assumption, a scatterplot matrix of the data would be produced to review the within-group variances.
4. The relationships among pairs of predictors in each group must be linear. Type, according to the MBTI, is scored linearly for all variables in the design (Mertler & Vannetta, 2005).

## CHAPTER 4

### RESULTS

Three hypotheses were examined for this current project. This chapter will address the results found. The first hypothesis addressed was whether or not those who were susceptible to functional fixedness were also susceptible to effects of Einstellung. I would fail to reject the null hypothesis if there were no significant relationship found between those who suffer from functional fixedness and those who suffer from effects of Einstellung. To determine whether or not those who were susceptible to functional fixedness were also susceptible to effects of Einstellung, a chi-square analysis was used.

The remainder of the research questions focused on the relationship between MBTI type preference scores and level of fixation. The first analysis examined if type was related to level of cognitive fixation. I would fail to reject the null hypothesis if there were no significant relationship found between MBTI type and level of fixation. A chi-square statistic was used for this analysis.

The second question addressed was whether or not there are significant relationships among preference scores obtained on the MBTI across levels of fixation. I would fail to reject the null if no significant correlations were found between preference scores obtained on the MBTI and level of fixation. Initially, discriminant function analysis was chosen to assess the relationship between personality type and cognitive fixation. As the sample size was too small to allow for this analysis, correlations were run to determine if the relationships between personality type and level of cognitive fixation were significant. Significant correlations were

followed with a regression analysis to determine if the preference scores interacted to predict level of fixedness.

The third research question was whether there were significant differences in preference scores across levels of fixedness. I would fail to reject the null if no significant differences were found between preference scores obtained on the MBTI and level of fixation. ANOVAs were run to determine significant non-linear relationships that exist between the preference scores and level of fixedness.

### **Chi-Square Analysis**

#### **Testing Assumptions for the chi-square analysis**

When conducting a chi-square analysis, one must ensure that observations are independent. This assumption was met in this case as the two activities (Einstellung and functional fixedness) were independent of one another. Second, any participant must fall into one and only one category. Susceptibility for both measures is dichotomous. Either participants were or were not susceptible to effects of Einstellung and/or functional fixedness. Participants can only fall into one and only one category for either measure. All participants were included in the cross tabulation, and with degrees of freedom of 1, there were a minimum of five observations per cell. There were at least five participants per group from which data were obtained (Mertler & Vannetta, 2005). As all assumptions of the chi-square analysis were met, I am confident that a relationship would be discovered between susceptibility to effects of Einstellung and functional fixedness were such a relationship to exist.

#### **Results of Chi-Square Analysis**

Chi-square analysis did not reveal significant relationships between responders. There was no significant difference between those who were susceptible to effects of Einstellung and

those who were susceptible to functional fixedness,  $\chi^2 (1, N = 37) = 1.097, p = .30$ . Despite the lack of statistical significance, there does appear to be a relationship between the cognitive mechanisms involved in solving these two problems when participants are divided into three groups. Total level of susceptibility was calculated by combining the responses to both the functional fixedness and the effects of Einstellung tasks. Participants were then divided into groups according to their responses on the cognitive fixation tasks. The first group consisted of those susceptible to both functional fixedness and effects of “Einstellung. The second group consisted of those who were susceptible to either functional fixedness or effects of Einstellung, but not to both. The third group consisted of those who were resistant to both effects.

Approximately 60% (22) of individuals tested responded in the same manner to both the functional fixedness and the effects of Einstellung problems in that they either were susceptible to both problems meant to induce cognitive fix, or they were resistant to both problems (see Table 1). The chi-square was not significant at the  $p < .05$  level, therefore a direct relationship between those who were susceptible to functional fixedness and those who were susceptible to effects of Einstellung was not found. However, as a majority of individuals tested responded in the same manner to both problems, it is likely that there is a common mechanism linking the two phenomena.

Table 1

*Functional Fixedness and Effects of Einstellung Crosstabulation*

Susceptibility to Functional Fixedness	Susceptibility to Einstellung		Total (N)
	No (n)	Yes (n)	
No (n)	<b>7</b>	10	17
Yes (n)	5	<b>15</b>	20
Total (N)	12	25	37

*Note.* Those who responded in the same manner to both the FF and E designs are in boldface.

The chi-square analyses of independence performed for each individual dimension on the MBTI when total level of fixation was considered were found to be non-significant as well. No one dimension was found to have a significant relationship to cognitive fixation. The Extraversion/Introversion dimension results yielded the following:  $\chi^2 (2, N = 37) = 1.797, p = .41$ . The Sensing/Intuiting dimension also yielded nonsignificant results when compared to level of fixedness,  $\chi^2 (2, N = 37) = .059, p = .97$ . Thinking/Feeling yielded the following results:  $\chi^2 (2, N = 37) = 4.09, p = .13$ . Finally, Judging/Perceiving was found to be nonsignificant when compared to level of fixedness,  $\chi^2 (2, N = 37) = .78, p = .68$ .

### Correlations

#### Testing Assumptions of a Correlation

The primary assumptions one must consider when analyzing correlational data are violations of normality, violations of linearity of the data, and violations of homoscedasticity. The normal probability plot did not evidence violations of normality as the data fall along a linear pathway. One would expect either a bow-shaped pattern to indicate a skew to the data or an S-shaped pattern which would indicate extreme kurtosis. Neither of these patterns was evident. There were no violations of linearity to the data based upon this pattern. The plot of

residuals did not evidence violations to homoscedasticity. Correlations found can be assumed valid based upon the aforementioned assumptions.

### Results of the Correlation Analysis

When analyzing the total preference scores, a significant correlation was found between the Thinking/Feeling dimension and level of fixedness as well (see Table 2). When the difference preference scores were analyzed, no significant results were found (see Table 2). When the data for balance preference scores were analyzed results on the Judging/Perceiving dimension approached significance at the  $p < .05$  level (see Table 2).

Table 2

#### *MBTI Scale Correlations*

Preference Score	MBTI Dimension			
	E/I	S/N	T/F	J/P
Total	.177	.002	-.296*	-.001
Difference	.114	-.056	-.193	.009
Balance	-.184	-.112	-.073	-.266

*Note.* \* $p < .05$ (1-tailed);  $N = 37$ . E/I = Extraversion/Introversion Dimension; S/N = Sensing/Intuiting Dimension; T/F = Thinking/Feeling Dimension; J/P = Judging/Perceiving Dimension.

## ANOVA

### Testing Assumptions for ANOVA

When conducting ANOVA, one must consider a number of assumptions regarding the data. The data are assumed to be normally distributed, observations must be independent, and equal error variance across dependent variable groups must be assumed. There are two tests that are commonly used to test the normality of data, the Kolomogorov-Smirnov and the Shapiro-Wilk tests. Neither of these tests yielded results that would indicate abnormality for the data obtained. Error variance appears to be within normal limits across dependent variable groups as

Levene's test was not found significant. Were this test significant, it would indicate unequal population variance making the results of the ANOVAs obtained questionable.

### **Results of ANOVA**

To examine differences and possible non-linear relationships between personality dimension and level of fixedness, separate ANOVAs were conducted. The analysis of the total preference scores and difference preference scores yielded no significant results. The analysis of the balance preference scores yielded results from one ANOVA that approached significance on the Extraversion/Introversion scale,  $F(1, 36) = 2.983, p = .064$ . As the results were not significant, I failed to reject the null that the personality dimension means were significantly different from one another when considering level of fixedness as a factor. Therefore, no further analysis was necessary or attempted.

### **Summary of Overall Results**

Overall, it does appear that susceptibility to functional fixedness and effects of Einstellung are related to personality preference scores on the MBTI. However, preference type on the MBTI is not able to predict predilection to functional fixedness or effects of Einstellung. It is likely that there is a similar cognitive mechanism involved in solving both functional fixedness and effects of Einstellung problems as 60% (22) of the participants involved responded to the problems in the same manner, either solving both correctly indicating a resistance to cognitive fix or solving both incorrectly indicating an overall susceptibility to cognitive fix.

A significant negative correlation was discovered on the Thinking/Feeling dimension (see Table 2). When data were coded for total items endorsed on each dimension scale, higher scores on the Thinking/Feeling dimension in the direction of Thinking correlated with more resistance to functional fixedness and effects of Einstellung. This finding indicates that there is a

relationship between personality type, as assessed by the MBTI, and susceptibility to cognitive fixation.

When data were coded to determine how balanced a profile was between the dichotomous variables for each dimension, two findings were approaching significance. There appears to be a slight correlational relationship between level of balance on the Judging/Perceiving scale and a potential non-linear relationship between level of cognitive fixation and the Extraversion/Introversion scale. These findings were not statistically significant and therefore cannot be interpreted as conclusive. However, given the small sample size these findings do suggest a possible relationship between cognitive fixation and personality.

## CHAPTER 5

### DISCUSSION

Previous researchers have revealed the phenomenon of both functional fixedness and effects of Einstellung (Duncker, 1945; Luchins, 1941). These researchers speculated about the factors involved in resistance to these two types of cognitive fix. Many researchers have emphasized the impact that personality has on problem solving (Luchins, 1941; Ramaprasad & Mitroff, 1984; Reiter-Palmon et al., 1998). Although it is a widely used and popular instrument, the MBTI has not previously been used to examine personality type as it relates to cognitive fixation. The current study examined this possibility. The findings of this investigation do not support the hypothesis that personality preference as assessed by the MBTI is a significant predictor of susceptibility to cognitive fixation. However, some relationships between personality and problem solving were discovered.

The results of this study indicate that an individual's susceptibility or resistance to functional fixedness does not determine their response to effects of Einstellung, although there does appear to be a relationship between the mechanisms involved for solving these types of problems as a majority of individuals tested responded in the same manner to the two procedures. Of the 60% of individuals who responded in the same manner to the functional fixedness and effects of Einstellung problems, only 18.9% of those were resistant to both effects. The remainder of this group, individuals who responded similarly to both problems, was found to be susceptible to both functional fixedness and effects of Einstellung.

Most individuals tested were found to be susceptible to both functional fixedness and effects of Einstellung. Fewer of the individuals tested were resistant to both functional fixedness and effects of Einstellung. This is slightly higher than what would be expected considering earlier findings. Duncker (1945) determined that approximately 15% of individuals are resistant to functional fixedness. Luchins (1941) found approximately 13% of his tested population to be resistant to effects of Einstellung. It is therefore surprising that such a high percentage of individuals (18.9%) were found in this study to be resistant to both of the tested effects. Earlier findings suggest that being susceptible to functional fixedness does not necessarily make one more susceptible to effects of Einstellung but that those who are susceptible to functional fixedness tend to be less resistant to extinguishing efforts with problems meant to induce the effects of Einstellung (Adamson & Taylor, 1954). It is possible that the sample size and the type of participants who volunteered for this project has something to do with this finding and it would be interesting to see if these results hold true over time with larger groups and/or different participant populations.

Personality preference was coded in three different ways for each dimension on the MBTI. Each of the four dichotomies on the MBTI was coded as continuous scores for each dimension. Rather than labeling an individual as either Extraverted or Introverted, the continuous score allowed calculation of degree of preference towards either one or the other extreme. Using the continuous scores, data were then coded to reflect (a) preference according to the total items endorsed for each dimension, (b) the direction of the preference for each dimension, and (c) the difference between one directional preference and the other for each dimension.

When the data were coded for total items endorsed for each preference dimension, a significant relationship was discovered between resistance to cognitive fix and the Thinking/Feeling dimension scores. It appears that those with higher preference for Thinking are less susceptible to functional fixedness and effects of Einstellung. Conversely, those with a higher preference for Feeling appear to be more susceptible to cognitive fix.

Thinking types are commonly described as those who value the objective over the participative (Myers et al., 2003). It makes sense then that those described as Thinking types would be more inclined to organize problems in such a way as to emphasize logic and practicality over congruence, especially when the pattern of responses on the effects of Einstellung problems is considered. Resistance to the effects of Einstellung requires that one view each problem as a separate entity to be solved in a novel and efficient way. The programmed response to these problems does yield a correct answer and creates a congruent pattern across all responses. It therefore requires less working effort in regards to one's thinking processes to solve the problems in a programmatic manner. Those resistant to the effects of Einstellung have to use an incongruent, yet simpler, method to solve the last two problems presented in the design. They must think through each problem separately, rather than viewing all problems presented as part of a congruent whole.

To solve the functional fixedness problem correctly, an individual must be able to see a novel use for a conventional item, in this case a box full of tacks. Those dependent upon previous experience would have a tendency to view the box as only a container. The novel problem solver must use practical logic within the context of the problem design to manipulate the box from cognitively categorized as "container" to being a "platform" from which to stabilize the candle. Participants with a high preference for Thinking appear to exhibit a problem-solving

style that is contextually dependent, allowing them to be resistant to both effects of Einstellung and functional fixedness problems.

When data were coded to identify the balance between dichotomies for each dimension, some findings approaching significance were discovered. Results nearing significance were obtained in regards to the balance of a Judging/Perceiving profile and susceptibility to cognitive fix. It appears that the more balanced the profile, or the more equally distributed the endorsement of items in each direction for this scale, the more susceptible an individual is to cognitive fix. It is possible that those who do not have a strongly polarized Judging or Perceiving preference have difficulty making decisions when solving problems. The style with which they approach problem solving, rather than allowing them to benefit from the strengths of both types, is muddled and leaves them less able to choose a focused approach to problem solving. Thus, these participants may be more susceptible to environmental stimuli and conditions during the problem-solving process, rather than engaging in a more internally influenced and independent analysis.

The other result discovered that approaches significance has to do with the ANOVA for the Extraversion/Introversion dimension. Though not significant, it appears that some of the variance of cognitive fix may be explained by primary personality preference for that dimension. It is possible that those with a more balanced Extraversion/Introversion profile on this dimension are responding in a similar manner to problems meant to induce cognitive fix. Either they appeared to be susceptible to both functional fixedness and Einstellung problems or they were resistant to both effects, suggesting a similar underlying mechanism. Those with more extreme type profiles, either leaning far towards Extraversion or leaning towards Introversion, were more likely to respond differently to the two problems. This indicates a possible connection between a

balanced Extraversion/Introversion profile and response to cognitive fixation. However, as these latter reported results were not statistically significant, this conclusion remains speculative based upon the direction of the data and is not conclusive.

### **Implications for Theory**

The results of this investigation appear to be congruent with results from past research. It does appear that there is a salient connection between the processes involved in solving both functional fixedness and Einstellung problems (Adamson & Taylor, 1954). However, susceptibility to one does not determine susceptibility to the other, leading one to argue that although the mechanisms involved may be related, it is likely that they are small parts of a more comprehensive process (Kearsley, 1975). Determination of the specific cognitive processes involved therein remains theoretical and beyond the scope of this current research.

As a significant relationship was found between scores on the Thinking/Feeling dimension of the MBTI and level of susceptibility to cognitive fix, one may infer that there is a salient connection between personality and problem solving. This result is further support for the theory that personality and organization of context play major roles in how one conducts problem solving (Duncker, 1945; Luchins, 1942; Maier, 1945). Personality is dynamically reflected in our interactions with the world. As the results of this study are interpreted to mean that a more balanced personality profile, specifically as it relates to the Judging/Perceiving dimension, leads to a higher susceptibility to fixation, it is also important to discuss what this may mean.

One may expect that a balanced profile would allow for an individual to pull from strengths on both ends of the dimensional spectrum for Judging and Perceiving. However, it appears that if the balance for these two preference types is too evenly matched then the

decision-making process is actually hindered. Those without a strong preference style on this dimension may find the decision-making process more difficult. Those with a stronger directional preference—with a larger difference between preference for one extreme or the other—potentially have less difficulty with the decision-making process as their decision-making style is more pronounced.

In common context, Extraversion and Introversion appear to refer primarily to social interactions. Though inconclusive, it is possible that one's type profile on this dimension also impacts the way that one interprets and interfaces with the world. As more extreme types on this dimension appeared to be responding in a different manner to the two problems, and those with more balanced profiles on this dimension responded similarly, it is possible that a relationship exists. Theoretically, one may say that those who exhibit and report having characteristics of both Extraversion and Introversion are more likely to exhibit more consistent responses to problem solving.

### **Implications for Clinical Work**

The results of this study imply that problem solving is a multi-faceted process, influenced by more than just personality. Intelligence, gender, mental illness, and age have all been shown to contribute to one's susceptibility to cognitive fix (Schultz & Searleman, 2002). Within the context of counseling, it is important to understand the way that individuals perceive and interact with their surroundings. Although cognitive fix is not the only reason why individuals fail to solve life's problems, it is likely a contributing factor in such cases as when one relies on past behavioral procedures at the expense of immediate contextual surroundings and indicators. Successful intervention requires an understanding of context-dependent and context-independent influences and requires the patience and effort to see life through the eyes of the client. After

further investigation, it is likely that more rather than fewer facets of the problem-solving process will be discovered to influence the dynamic interaction between personality and the world at large.

In both clinical and non-clinical environs, the MBTI remains a commonly utilized and practically useful instrument (Myers et al., 2003). Many individuals have found this tool to be reflectively helpful, and most tend to agree with the type profile they obtain as well as the information it provides (Myers et al., 2003). Though evidence that calls into question the validity and theoretical basis for this tool exists, it is difficult to judge the participative value of this instrument (McCrae & Costa, 1989). It is doubtful, however, that overall profile scores on this instrument are good indicators of problem-solving ability and susceptibility to cognitive fix.

It is potentially helpful in clinical application to know that having a clear preference on the Judging/Perceiving dimension can lead to less inhibited decision making. It is not so much that one style may be better than another but that having a clear preference is beneficial in order to streamline the decision-making process. Both styles appear equally as tailored to successful problem solving, so long as the individual has a clear preference for one style or the other. In clinical applications, it may benefit one to foster skills and strengths related to the style toward which an individual is already more inclined. If the magnitude of preference is only slightly exhibited towards Judging, then the clinician would do well to emphasize more strengths and skills commonly found for those with a Judging preference in order to increase the level of preference for that type. One might expect a person to have less difficulty with the decision-making process and less susceptibility to things like cognitive fix as their preference for one style or the other on this dimension becomes more pronounced.

### **Future Directions**

A great many personality inventories and assessments have been developed over the years. It is reasonable to believe that one of these instruments would relate to problem solving in a more statistically significant way. It is my continued belief that personality is one of many factors involved in successful problem solving. One potential project for the future would be to explore other measures of personality and how they interact with measures of cognitive fix.

Another direction for future research would be to continue to explore the cognitive mechanisms leading one to become functionally fixed and/or susceptible to effects of Einstellung. It is likely that there is a salient relationship between these two phenomena, even though the specific mechanisms involved remain elusive. Further investigation should focus on the relationship between functional fixedness and effects of Einstellung specifically and how they impact the overall problem-solving process.

### **Limitations**

One of the most obvious limitations of this project is sample size. Although a significant relationship was found between susceptibility to functional fixedness and effects of Einstellung on the Thinking/Feeling dimension, no significant differences were found between the means of the separate categories when ANOVA was used. As there were trends towards significance in other categories, it is possible that with increased sample size and subsequently increased power, more significant results would be found.

One way to improve the participation rate could be to provide a concrete incentive for participation. Although I am of the mind that participation in academic and campus activity is a personal benefit and privilege of student status in higher education, there are those who may disagree. It appears that only a small percentage of students is willing to give an hour of their

time to participate in research when there is no concrete benefit for doing so. As this study was limited to a student population as well, it is possible that higher rates of participation would be found were this study to have been open to the population at large.

Perhaps another way to improve participation would be to alter the design to be given via the internet. Asking a student to arrive at a certain physical location in order to participate likely prevented some people from participating. If the means of participation was more convenient and the activities could have been completed at an individual's leisure, it is likely that higher rates of participation would have occurred.

Another limitation of this design was the use of the MBTI. Although it is a widely used instrument, there are a number of concerns in regards to its validity as a measure and its theoretical base (McCrae & Costa, 1989). As the MBTI is a unique instrument, it is possible that other measures of personality type would have a more significant predictive relationship in regards to these particular problem-solving phenomena. Perhaps a measure more inclined towards assessing specific problem-solving styles, rather than overall personality preference, would have yielded more significant results.

### **Conclusions**

There are perhaps two main arguments one could make for the merits of this project. First and foremost, a relationship does appear to exist between the cognitive processes involved in working a functional fixedness problem and working problems meant to induce effects of Einstellung. Second, there does appear to be a sound relationship between personality factors as assessed by the MBTI and problem solving, however small. Thinking types, according to the MBTI, appear to be more resistant to functional fixedness and effects of Einstellung. Conversely, Feeling types tend to be more susceptible. Overall, a predictive relationship

between personality type and cognitive fix was not found with this study. A larger sample would perhaps yield more conclusive results and explain a greater portion of the variance for problem solving. All in all, the specific mechanisms involved in cognitive fix and the personality factors that contribute to susceptibility and/or resistance to these effects remain for further exploration.

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## APPENDIX A: CONSENT FORM

**CONSENT TO PARTICIPATE IN RESEARCH**

## Problem Solving and Personality Preference

You are asked to participate in a study conducted by doctoral candidate James W. Erikson, M.Ed. and his dissertation chair Damon Krug, Ph.D., from the Department of Communication Disorders and Counseling, School, and Educational Psychology at Indiana State University. This project is being conducted as part of a graduate dissertation requirement. Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand, before deciding whether or not to participate.

You have been asked to participate in this study because you are a current undergraduate student in EPSY 202 or EPSY 341 at Indiana State University. Approximately 140 students will be recruited to participate in this study. If you have reason to believe that your prior knowledge of these problem examples may alter the results of this study, you will be excused from participation.

**• PURPOSE OF THE STUDY**

The purpose of this study is to examine the relationships that exist between non-clinical personality preference and problem-solving methods.

**• PROCEDURES**

If you volunteer to participate in this study, you will be given more explicit instructions from a research assistant momentarily; however, the basic procedures are summarized in the following bullet points:

- Complete a multiple choice questionnaire that will result in a non-clinical personality profile to be used in the analysis of this research design (approximately 30 minutes)
- Complete a series of math based problems with visual aids provided (approximately 15 minutes)
- Answer a problem using reasoning skills based on the scenario provided (approximately 15 minutes)

The research assistant present will randomly assign you to a research group. This will be based on an assigned research number. In total, it should take approximately 60 minutes or less to complete all procedures for this study.

**• POTENTIAL RISKS AND DISCOMFORTS**

The risks of participation in this study are thought to be minimal. Should you choose to participate, you will be asked to engage in behaviors and cognitive processes similar to those that would be expected of the average college undergraduate.

**• POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY**

The results of this study will benefit the academic community by providing supplementary information about the relationships between personality preference and problem-solving processes. There will be no direct benefits to the participants involved in this study.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. All data will be coded in such a way that individual participants will be identified by only an assigned number. Confidentiality will be maintained by keeping all data in a locked room, inside a locked file, or on a password protected computer in a password protected file. The research assistants will only have access to raw data. The primary researcher will perform all data analyses. He and his dissertation advisor will have sole access to analyzed data prior to dissertation completion. Data analyses will be presented generally and will not be used to identify particular study participants. All data forms will be kept for three years and then destroyed.

- **PARTICIPATION AND WITHDRAWAL**

You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits to which you are otherwise entitled. You may also refuse to answer any questions you do not want to answer. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about this research, please contact James W. Erikson, M.Ed. (primary researcher) at [jerikson@indstate.edu](mailto:jerikson@indstate.edu) or Damon Krug, Ph.D. (faculty sponsor/dissertation chair) at [Damon.Krug@indstate.edu](mailto:Damon.Krug@indstate.edu) or 812-237-7785.

- **RIGHTS OF RESEARCH PARTICIPANTS**

If you have any questions about your rights as a research participant, you may contact the Indiana State University Institutional Review Board (IRB) by mail at Indiana State University, Office of Sponsored Programs, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at [irb@indstate.edu](mailto:irb@indstate.edu). You will be given the opportunity to discuss any questions about your rights as a research participant with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with ISU. The IRB has reviewed and approved this study.

*Leave this amount of space  
for IRB approval stamp (unless  
you plan to include the approval  
information in the text of the ICD)*

APPENDIX B: DEMOGRAPHICS FORM

Demographics Form (example)

**Research Participant:** #0001

**Age:**

**Sex (circle one):** Male      Female

**Race/Ethnicity (circle one):** White/European American

African-American

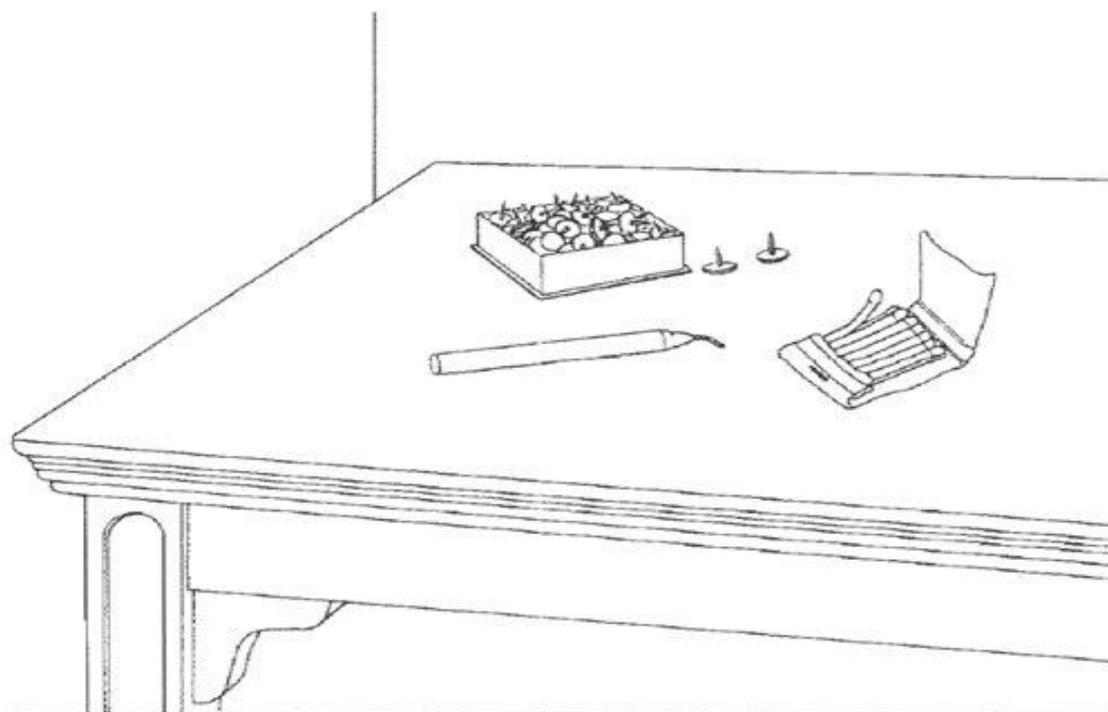
Latino/Hispanic-American

Asian-American

Native American/American Indian

Other

## APPENDIX C: CANDLE-BOX PROBLEM

**Instructions:**

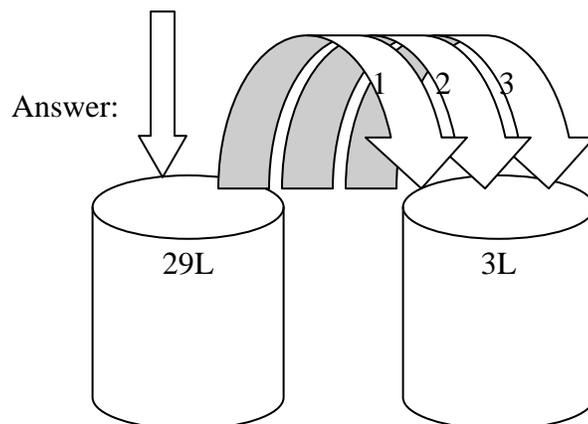
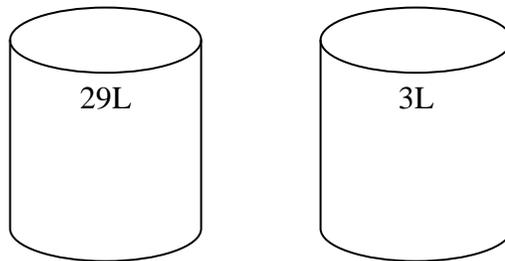
Using only the materials shown on the table, obtain the following solution. The problem is considered solved when the candle can be firmly affixed to the wall, burn properly, and does not drip wax on the table or floor.

## APPENDIX D: EINSTELLUNG PROBLEMS

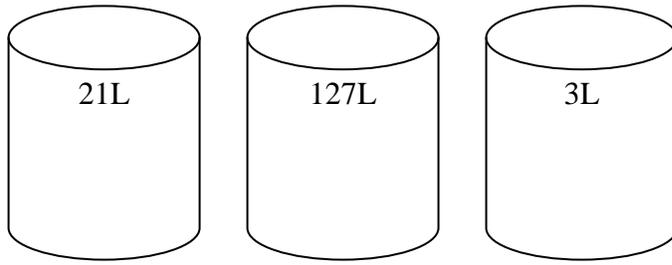
Instructions:

Your task is to figure out on paper how to obtain a required volume of water, given certain empty jars for measures. Indicate a full filling of a jar by drawing an arrow in the chosen direction.

Example: Get 20L

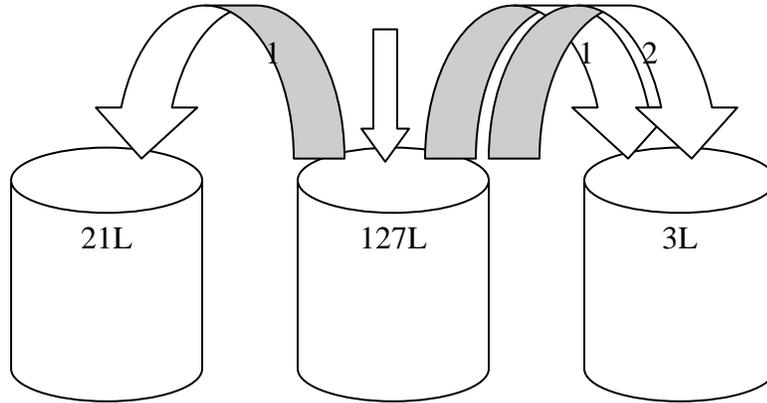


Get 100L

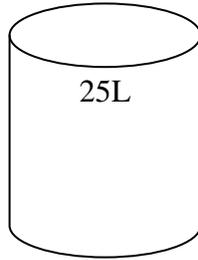
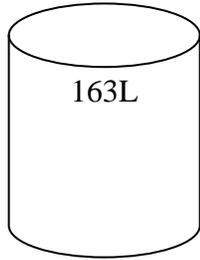
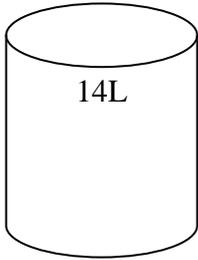


Answer:

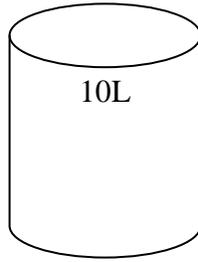
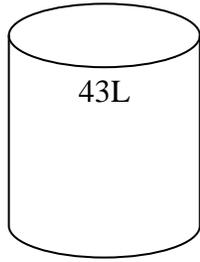
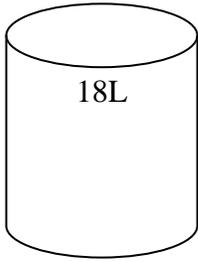
One fills the 127-liter jar and then from it fills the 21-liter jar once and the 3-liter jar twice. In the 127-liter jar there then remain 100-liters of water.



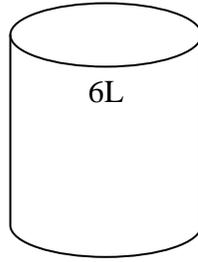
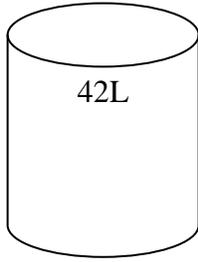
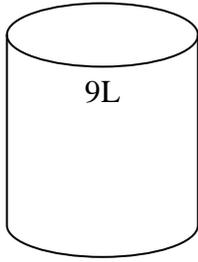
Get 99L



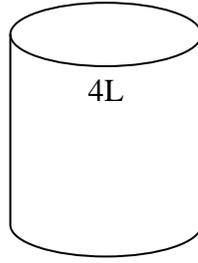
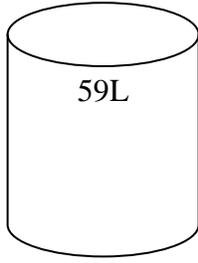
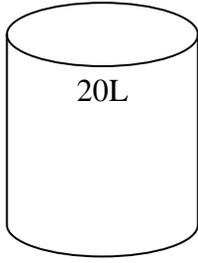
Get 5L



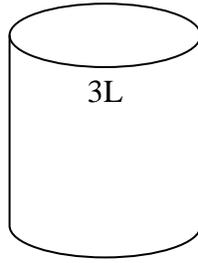
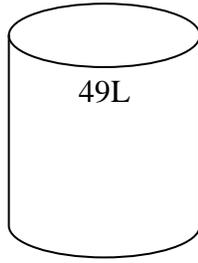
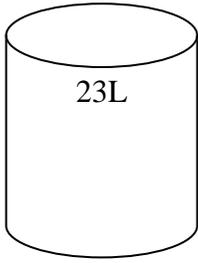
Get 21L



Get 31L



Get 20L



Get 18L

