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The Effects of Negative Priming and Time Pressure on Creative Problem Solving

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Abstract

This paper examines the effects of negative priming and time pressure on creative problem solving, as measured by originality and practicality. In terms of negative priming, this paper builds on the work of Smith (1995, 2003). A negative prime is an example solution to a task that incorporates undesirable features, and is given to participants before they begin the task. In particular, attention is paid to Smith's "coffee cup" paradigm, where participants asked to design as original a spill-proof coffee cup as they can will incorporate many basic features of the example which they are given, even if those features are detrimental to the function of the cup. Work on time pressure in various contexts is reviewed, as well as the cognitive load imposed by time pressure. Expected conclusions include main effects of time pressure and negative priming, and an interaction demonstrating a different effect of negative priming when time pressure is involved. Simply stated, time pressure leaves less time for participants to overcome the effect of negative priming, whatever specific strategy they use to do that. Actual results were significant interactions of the two variables for originality and quality/clarity, and a main effect of time pressure on originality, practicality and quality/clarity, but no main effect of negative priming, although the negative priming effect was in fact replicated. Implications of this result on the definition and operationalization of creativity is examined. The possibility that these results represent reliance on a different cognitive strategy, such as heuristics as opposed to algorithms, is examined. Applications to basic research in cognition, and to applied research decision-making are discussed.

The Effects of Negative Priming and Time Pressure on Creative Problem Solving

Generally, creativity is not a central concern for people, because people just want things to work, usually relying on methods that have worked in the past. Sometimes, however, problems prove intractable or previous solutions no longer suffice. Then, we need a creative solution to that problem. That is to say that, many times, a problem remains a problem because previous attempts to solve it have been unsuccessful. In such a situation, repeating the failed solutions or methods that yielded no positive results for previous decision-makers would not help to solve the problem, and would probably cause us a significant amount of frustration in the process. What we want, then, are creative or novel solutions. We want, solutions, in other words, that have not been tried or attempted before. There are, unfortunately, several factors that can inhibit the development of such a solution. As we shall see, two of those are time pressure and the constraining effects of prior examples.

Mandler (1995, p. 9) defines creativity as "the production of something novel," in other words, something new and different. In an effort to clarify that definition, and perhaps to limit allegations that it is circular, Mandler (1995, p. 10) also says that novelty "exists in a social context…[and] may be novel for all of humanity, for a specific social-cultural unit, or for an individual." Thus, something is creative when it is new to the person or population who created it. The social context that Mandler identifies as inherent in creativity would necessitate that the results of creative processes be useful to the individual or society, in the broadest possible sense of the word.

Useful, of course, is a relative term, not meant in any way to be normative. Usefulness is determined solely in the context of helping to solve the particular problem,

so that if the problem involves, for instance, designing a new toy, the most useful responses would be those designs that were not simply reformulations of toys already on the market. Put another way, even the creation of art would fit this explanation of creativity. Art is useful so long as it fulfills the goals of the artist, which usually is to create some reaction on the part of viewers or the artist himself.

Mandler (1995) makes a further differentiation between different degrees of creativity. That is to say that something can be more or less creative than something else. Creativity, therefore, is not a dichotomous variable that one either possesses or does not. In addition, even among two (or more) novel solutions, one can be more creative than another because it has less in common with previous solutions, from which, by definition, creative solutions distance themselves.

One should also note that in many problem-solving circumstances, the creative solution is likely to be the better solution in terms of an objective judgment. The reason for this is that a problem, by definition, has remained a problem because previous attempts to solve it have been at most only partially successful. We do not try to create new ways to do things when the old way is completely satisfactory. Therefore, creative solutions are those that distance themselves from solutions that have not fully worked in order to, one hopes, find different solutions that do work. Thus, in situations where we are trying to be creative, we also *want* to be creative. That is to say that it is much easier to follow a procedure that we already know than to generate a new one.

While we have adequately defined creativity, we are still left with the question of how it comes about. Weisberg (1993) uses historical case studies of significant scientific breakthroughs to argue that important creative discoveries are usually made by one of a

few possible processes, implying that the process behind creativity is not as extraordinary or mysterious as it may seem. Smith gives us an idea of how difficult it is to develop a theory of creativity when he points out two contradicting pieces of prevailing wisdom. As the common sayings go, we need to "stand on the shoulders of giants", but we also need to avoid getting "stuck in a rut" (Smith, 2000).

Prior knowledge can have negative effects, but, far from being bad, prior knowledge is actually necessary in problem solving. In situations where we just want to solve a problem as quickly as possible, and have successfully solved that problem before, we want to use that prior knowledge to replicate that previous solution. In addition, even when we are developing a creative solution, prior knowledge gives us a starting point, so that we are constantly moving towards a solution and not merely trying things that have been tried unsuccessfully before.

In Smith, Ward, and Finke's (1995) creative cognition approach, there is room for both of these viewpoints with regards to the effects of prior knowledge. Essentially, prior knowledge can have both positive and negative effects, quite possibly simultaneous ones. The authors admit that, whatever else the negative effects of prior knowledge may be, we need it because it serves as a starting point and illuminates a path in any problem, as prior knowledge tells us what has already been tried in the past, what has succeeded, what has failed, and, most importantly, what is most likely to succeed in the future.

Related to this is the role of prior knowledge in novel insights. An insight is a solution that comes to a person suddenly and without warning, and is oftentimes simply the rearrangement of prior knowledge in new ways to generate a creative solution. Insight can occur when a person is working on a problem, such as a puzzle or brain-teaser

where it is impossible to measure progress until a solution is found, but more often insight occurs after the problem has incubated for some time (Smith, 2000). Incubation refers to the period during which, after attempting unsuccessfully to solve a problem, a person will move on to a totally unrelated task, and then suddenly think of a solution for the task they had stopped. This documented incidence of novel solutions arrived at via insight following incubation would seem to imply that an unconscious process is at work in creativity (Smith, 2000). Silviera (1971) took a slightly different view, however. The results of her "cheap-necklace problem", which involved more subjects solving the problem as the length of the break they took in the middle of solving the problem increased, suggested that incubation effects were largely due to subjects forgetting set effects. Recall that a set effect is the bias that develops towards the initial attempted solution, so that alternatives are not considered. By getting the chance to start the problem over, subjects could approach it anew, and the initial way in which they approached the problem the second time would lead to different set effects than the first time, or possibly to none at all. This is usually how "insight" is explained.

Prior knowledge can predispose a subject to generate certain solutions in certain situations. This phenomenon is referred to as priming. Priming can be either positive or negative. Positive primes would increase the ability of a person to solve a problem. They are words or cues that stimulate, as oppose to inhibit, the retrieval of later targets (Reed, 2000). For instance, after viewing a list of words which contained the word "doctor", a participant will be more likely to recall the word "nurse" on a subsequent test in which nurse is the correct answer, and will also recall the word faster.

Negative primes would inhibit the creative solution of a problem (or any solution at all, in some cases) by acting as a blocker to the correct solution. Smith clearly demonstrated the effects of negative priming by presenting participants with a list of words, and then giving them other words with letters left out, a procedure known as a word-fragment completion task. When presented with the word "allergy" as part of the original list, for example, subjects had trouble solving the problem "al-e--ry". The word "allergy" acted as a "blocker" so that participants could not retrieve the correct solution from memory, which was "allegory". This effect was prevalent even when participants were explicitly warned to ignore the list of words they had been read in solving the problems (Smith, 2003).

Smith's work also demonstrates one other characteristic of problem solving. Once a response has been retrieved, the likelihood of retrieving it again increases, because the response has become active in working memory (Smith, 1995). Thus, after retrieving the same wrong answer a number of times, a participant might become "stuck" on a particular problem. Participants can also become stuck in a trap of using the same solution to a series of problems, even though, for some problems in the series there exists an easier solution. One demonstration of this is the Einstellung effect (Anderson, 2000). Originally demonstrated by Luchins, it involved giving participants a math problem in which they had three jugs that held different amounts of water (A,B, and C), and had to figure out how to use those jugs to achieve the desired amount of water. For the first five problems, the only possible solution was B-2C-A. However, for the sixth problem, there exited an easier solution (A-C), however most participants used the earlier more difficult solution that was active in short term memory and thus subject to biased retrieval.

The implication of this work is of particular importance for those involved in group decision-making. Logically, one can expect that, in a group brainstorming session, the first proposal put forward would prejudice a group toward retrieving the same or similar proposals for the duration of their brainstorming. Written pre-meeting brainstorming by individuals might help alleviate this problem, though.

One could question Smith's method, because participants had no systematic series of steps with which to work. The problem, in other words, could not be solved in a stage-like process (like mathematics) and was insight-based rather than incremental. The participants had no set of steps upon which to base the development of a creative solution to the problem. Thus, the exact onset of the blocking effect, and the exact process on which it acted within the temporal sequence of creative idea generation, is unclear. Insight problems are problems where the answer suddenly and unpredictably comes to you after you have been trying the problem for a long time and letting the problem incubate (Schooler & Melcher, 1995). The word example above is an example of an insight problem, because you cannot tell how far you are from finding the answer, it just suddenly comes to you. Insight problems, then, also demonstrate poor metacognitive control. The subject was not able to ignore blockers and solve the problem when it was originally presented. Incremental problems, on the other hand, can be solved in a stage-like process, so that the subject knows approximately where he or she is in the process and how long it will take to finish.

Smith has, however, also demonstrated the effect of negative primes in two separate incremental tasks (Smith, 1995, 2003). In the first task, Smith asked a group of students to draw a hypothetical alien that would develop on an earth-like planet far, far

away. The students were given examples, all of which contained four legs, antennae, and a tail. The students' designs varied from the examples in important ways, but almost all included the features with which the students had been primed: four legs, antennae, and a tail. This effect was observed even after students were told to draw aliens as different from the examples as possible.

Even more striking was an example in which Smith (2003) asked a group of engineering students to design a spill-proof coffee cup, and then presented examples with several obvious mistakes (or at least, mistakes that would be obvious to engineers). Note that this example more clearly illustrates the *negative* dimension of negative priming, in that not just unoriginal but undesirable features are incorporated into the designs. Most engineering students in the experiment incorporated the negative features of the example designs into their own designs, even when specifically told that they were seeing bad examples and to avoid emulating them. Thus, one sees how negative priming works here: the negative primes act as blockers, making participants unable to retrieve alternate responses that they clearly have the knowledge to generate, even when they consciously try to do so.

One could conceivably question why negative priming is called "negative" at all. It is, after all, similar to priming in that those subjected to it are unable to overcome it to solve a problem. Negative priming is negative because of its effects. Negative primes make a problem harder to solve by priming a subject with information that distracts from finding the correct solution. The phenomenon of priming itself, though, is not necessarily good or bad. If the priming does not significantly impair the finding of a solution, or if the problem is not important so that an uncreative solution is not necessarily undesirable,

then the priming is not negative. Put another way, the process of priming is a single consistent physiological process. What makes it negative or positive is the effect of the prime on the solution, not the actual process of priming itself.

Priming (knowledge presented just prior to the task) and prior knowledge (present in long term memory prior to the experiment) could both have similar effects independently. That is to say that both provide the subject with some fund of knowledge from which they can draw on at the onset of the task and in initial planning, because the knowledge was obtained before the presentation of the task. Priming can do this because, as we have seen, it is presented before the experimental task and will be drawn on in the performance of that task. Prior knowledge can do that because a subject will draw on prior knowledge to have some idea how to complete a task in the absence of instructions that would prime the subject. Both priming and prior knowledge, then, help subjects to complete the task more quickly than they otherwise would have by giving them a cognitive road map from which to plan. Furthermore, one could assume that the effects of priming and prior knowledge interact. That is to say that subjects will perform faster in a task for which they have prior knowledge and are primed than they would perform in a task in which neither priming nor prior knowledge is present.

Priming is only one variable that can affect performance. Another such variable is time pressure. For example, George (1980) and Mann and Tan (1993) and Hahn, Lawson & Lee (1992) all identify time pressure as having a negative impact on decision-making performance and each reaches that conclusion studying decision-making in a markedly different context. George (1980), for example, studied the foreign policy decision-making process of United States presidents. He attempted to identify the

impediments to effective decision-making. He identified several such factors through case studies of crisis decision-making in presidential administrations, with particular emphasis on JFK and the Cuban Missile Crisis, and FDR and Pearl Harbor. Among the factors George identified were a reliance on only one stream of information, near-unanimity of opinion in a group of advisors where not every viable option has an advocate, human prejudices, and time pressure. The effect of time pressure was mainly to prevent consideration of every alternative in turn, thus creating a situation that relied heavily on heuristics, and where the first option was implemented so that at least *something* would be done in time.

A definition of some decision-making terms might be helpful here. Problem solving strategies are often discussed in terms of heuristics and algorithms. A heuristic is a strategy that is sometimes helpful in solving a problem, but won't always work. The availability heuristic is a specific kind of heuristic that employs the strategy of "estimating probability by the ease with which examples can be recalled" (Reed, 2000). In other words, the availability heuristic is sometimes helpful, but since you can recall some examples more easily than others, you will be likely to make biased estimates of outcomes. Thus, your creative product may simply be the first thing to come to mind, which, as demonstrated by the research on positive priming, may in itself be the last thing you saw, or, put another way, your biased retrieval set. Keep in mind that under time pressure, there is even less time to recall examples than would normally be available. Thus, under time pressure, the availability heuristic would produce results even more skewed than usual.

An algorithm, on the other hand, is "a set of rules that will solve a problem if correctly followed" (Reed, 2000). For example, the algorithm for finding the mean of a set of numbers is "divide the sum of the set of numbers by the number of elements in the set." That method will always yield the correct answer if it is correctly followed. Given the time involved in retrieving and using algorithms, as well as the possibility that heuristics are effective in many cases, a decisionmaker might be inclined to use heuristics as a sort of cognitive shortcut to decrease cognitive load in problem solving under time pressure. Keep in mind, though, that since most complex real-world decisions are unique, the exact algorithms for solving them are not known or may not exist because the problem might be ill-defined.

The relationship between decision-making and problem solving, and the relevance of both to creativity, deserves some explanation. Decision-making is a choice among alternatives, and problem solving involves, at least in part, the generation of ideas in response to a creative task. The geneplore strategy, where participants are instructed to come up with as many initial solutions to a creative task before evaluating or eliminating any, is an example of this relationship (Reed, 2000). In other words, creativity involves first problem solving, and then decision-making once several ways to solve the problem have been identified. In addition, the decision on how to approach a creative task is, in itself, a decision, subject to all of the same inefficiencies as any other decision. Thus, what the current experiment deals with is not just straight creativity, but rather can be conceptualized as creative problem solving, or as decision-making designed to foster creativity.

Mann and Tan (1993) studied decision-making in a business context. Corporate managers are usually required to make complex decisions and weigh a large number of factors. Such decisions are usually difficult enough, without any outside interference, given the limited capacity of working memory. They might even be excessively taxing on the cognitive resources of weak managers who, for one reason or another such as performance anxiety, are prone to making poor decisions (Man and Tann, 1993). Mann and Tan also discovered that the *perception* of time pressure, even when significant time exists to make a decision, can result in a decline in the quality of the decision. Indeed the title of their article gives this conclusion away: the "hassled decision maker" will be more likely to make a less than optimal decision, even when significant time (and, presumably, information) exists to make that decision. The optimal decision would result in the most benefits with the fewest costs, thus the further from "optimal" you go, the more negative effects the decision creates.

In the context of consumer decision-making Hahn and his colleagues (1992) try to determine how decisions are made under time pressure with different amounts of information. The primary factor they identified was the load capacity of the individual's working memory, or, in other words, the amount of information that an individual can effectively process. They found an inverted U-shaped curve, meaning that decision quality suffered when there was either less *or* more information than was necessary, similar to the results of the Yerkes-Dodson study (1908). With too little information, an effective decision cannot be made because there is no basis for making a decision. With too much information, the decision cannot be made effectively because the information cannot be processed and considered within the time allotted. It is also important to note

that the U-shaped curve was not present when the constraint of time pressure was removed. That is to say that, in general, more information leads to a better decision in a linear function. It is only in the context of a time constraint, then, that the imposed cognitive load actually affected decisionmaking performance.

In many of these experiments on time pressure, participants have known from the start of their work that their was some sort of time limit on the solution, or, in other words, that they were under some kind of time pressure. It is a well-settled fact in psychology that significant time pressure will create, at least in some subjects, some anxiety (Salanova et. al, 2003). The link between anxiety and decreased performance has also been well demonstrated previously by Yerkes and Dodson (1908). They originally determined that optimal performance would occur when there is neither too much nor too little anxiety. Thus, for subjects who experience anxiety over the prospect of time pressure, decreased performance would be expected.

While the link between anxiety and performance has been studied extensively for the last century, the link between time pressure and the creativity of performance, or creative problem solving, is still unclear. This is especially true in situations where it is quite easy for subjects to rely on heuristics or simpler strategies to complete the task and avoid the need for the creative process which is cognitively more taxing.

If we assume that time pressure produces some anxiety in most people, the work of Zajonc and his colleagues (1969) and Michaels and his colleagues (1982) becomes valuable. They found two interesting, and related, things. First, experts thrive on the kind of anxiety generated by being watched, while novices do not. Secondly, when people are being observed, they tend to revert to previously well-learned and well-

practiced behaviors, even if they just learned a new skill. If we believe that time pressure creates the feeling of having an audience that Zajonc and Michaels describe (or produces similar anxiety) it would be logical to assume that people will fall back on well-learned heuristics rather than use algorithms, which are for most people the less-practiced alternative.

It is certainly conceivable that when people know they are under time pressure, they will attempt to work faster. Such an attempt would likely result in the exclusion of difficult components of tasks on the part of the subject whenever possible, and also on a reliance upon what is already known and done. For instance, in designing a spill-proof coffee cup, the subject might focus on what he knows about the characteristics of the coffee cup which he used that morning, because that would be the first occurring thought, and the subject would feel the need to get something immediately down on paper to ensure task completion. Thus, one could logically expect time pressure to inhibit creative performance.

The preceding theoretical discussion of creativity is inconclusive without some empirical investigation. Empirical investigation is certainly possible, because, although creativity is a theoretical construct, there are fairly well developed ways to observe and measure it. Creativity is also a field available for study because, although much creativity research focuses on case studies of after-the-fact decisions, it is also possible to manipulate and measure creativity in a more experimental setting, thus solving the problems of low reliability and low validity inherent in ex post facto research. One way of testing a person's creativity is by using the Remote Associates Test (RAT) with negative primes (Smith, 1995). The RAT (Mednick and Mednick, 1967; see also

Michalko, 1991) consists of several groups of three words (for example: family, apple, and house). The object is to come up with a word that would form a compound word or two-word phrase when placed either in front of or behind each word. In the example above, "tree" is the solution because it forms the phrases "family tree", "apple tree" and "treehouse".

If one wanted to use a negative prime, it consists of the presentation of a list of words before the test which will match one or two words in a given three-word set, but will not be the correct solution. According to the theory of negative primes, such words will act as blockers (such as "green" in the example above) and will further inhibit the retrieval of the correct solution with each subsequent retrieval of the blocker. Thus, overcoming the blocker requires meta-cognitive regulation to produce creative thought, in order to consciously overcome a blocker. Thus, the score on the RAT should correlate positively with other measures of creativity.

In the present experiment, I will utilize Smith's procedure of designing a spill-proof coffee cup. I will present this procedure under four conditions: to two groups under time pressure, one of which receives the negative prime (examples of coffee cups containing design errors) and the other of which receives no prime. A second two groups will be tested under the negative prime and no prime conditions without time pressure. This will yield a 2x2 factorial design, with four independent groups. Designs will be scored for originality and practicality, with higher scores obviously indicating more creativity.

I expect main effects of both time pressure and negative prime. The absence of time pressure should lead to better performance as measured by the originality and

practicality scores, as should the absence of a negative prime, as measured by the same two scales. Furthermore, I hypothesize an interaction, because there should be a greater negative effect of time limit in the negative prime group than in the group with no negative prime, reflecting perhaps the use of a different cognitive strategy under the influence of a negative prime.

Method

Participants

Participants were 114 undergraduate students enrolled in Introduction to Psychology at Hofstra University, and they participated for course credit. Anonymity was assured, informed consent was obtained, and participants were told that their performance on this exercise would have no effect on their class grade.

Raters

Two advanced undergraduate engineering students at Hofstra were paid $100 each to rate the designs of the participants. These raters were kept unaware of the specific condition to which each of the designs they rated belonged. To control for any possible order effects, each rater looked at the designs in a different randomized order.

Materials

Participants were provided paper and pens to sketch with. For the negative-prime conditions, Smith's (2003) negative prime was used (see Appendix 1). A copy was provided to each participant in a negative- prime condition. A negative prime is an example given to participants before they start the task that contains negative features (although the participant is not told this). The theory is that the negative features of the example will be incorporated into the participant's design even when the participant is

instructed to make a design as different from the example as possible, because the presence of the example will restrict creative thinking. All participants will receive a written instruction sheet as well, containing the procedures outlined herein, which will also be read aloud. The directions put particular emphasis on the fact that this experiment was designed to produce designs other than those commonly used, so that participants should try to make their designs as original as possible. Participants were also given a post-test questionnaire where they were asked to rate their performance, as well as written debriefing.

Design

This experiment is a 2x2 between subjects factorial design. The two independent variables are time pressure and negative priming. The dependent variables are the originality and practicality scores assigned by the raters. The originality and practicality of each design will be rated independently by both raters on a 1-5 scale. Both measures are subjective, and based upon the engineering knowledge of the raters. As a way of determining how closely participants followed the directions of the exercise to design a spill-proof coffee cup, raters were also asked to rate on a 1-5 scale how likely the cup was to tip, and, if it did tip, how likely it was that coffee would spill out. Raters were also asked to rate the clarity of the design and the similarity of the design to the negative prime, as a way of checking that participants were in fact under time pressure or primed, respectively.

The responses to the post-test questionnaire were also treated as dependent variables in a separate analysis. All participants were asked how original, how practical, and how creative they believed their designs to be, and to answer those questions using a

1-5 scale. In addition, participants in a negative prime condition were asked how similar to the prime they believed their design to be, and participants in a time pressure condition were asked how anxious they were about finishing within the time limit, and whether they could have made a better cup if they had had more time. These questions were intended to explore the specific mechanisms and meta-cognitive aspects of creativity in the event that the expected main effects and interaction were obtained.

Procedure

All participants were introduced to the task by being told that their job is to design a spill-proof coffee cup and to sketch their design on the paper provided. They were told to label the parts of their sketch for easy identification. Participants were told to draw their design from as many angles as possible to ensure full consideration by raters of the design's merit. Participants were told to come up with a design that is both original and practical, as their design would be scored separately on those two criteria. In addition, participants were told that no straws are to be incorporated into the design, following the procedures of Jansson and Smith (1991).

The negative prime groups received Smith's negative prime, and additional instructions that this is an exercise designed specifically NOT to have them rehash designs that have already been done, and therefore they should be as original and creative as they can: their designs should therefore be as different from the example as possible.

Participants in a time pressure condition were informed of the time limit, and told that they will need all that time in order to complete the task. The time limits were derived by running the non-time pressured groups first, and computing separately the average completion times of the negative prime and no-prime groups, and then setting the

time limits as one-third of those averages. Thus, time limit was set at ninety seconds for those not receiving a negative prime, and at two minutes for those that were negatively primed. Different time limits for the negative prime and no prime conditions were necessary because it became apparent that it took participants a significant amount of time to look at and process the negative prime before they could start their design. Participants not in a time pressure condition were told to take as much time as they needed to complete the exercise.

While this experiment generally followed the methodology of Jansson and Smith (1991), there was one important difference. Jansson and Smith asked participants to draw multiple designs, and then computed creativity by dividing the number of designs that were negatively primed over the total number of designs generated. In addition, the number of designs generated, known as the fluency measure, was considered in itself to be an indicator of whether a participant had overcome the negative prime.

The addition of the time pressure variable meant that such a methodology would not have worked for me, because under time pressure people will obviously generate less designs, not because they are necessarily less creative but simply because they had less time. Thus, I chose to have participants draw one design, with instructions to draw it from as many angles as possible. In a way, perhaps I have managed to measure creativity more rigorously than Jansson and Smith did, because having participants draw only one design likely provided for a more in-depth sketching of that design, and made possible a more thorough appraisal of its creativity. This difference might explain if, perhaps, the designs generated in my experiment were less creative than those in Smith's experiment,

or if my designs were more frequently identified as negatively primed due to the greater specificity of the instructions given to the raters.

Results

There were four groups in this study. The no time pressure/no negative prime group had twenty-five participants, the time pressure/no negative prime group had thirty-four, the no time pressure/negative prime group had twenty-four and the time pressure/negative prime group had thirty-one.

Two raters, blind to the purpose of the study and to the group to which any particular design belonged, used a five-point scale to rate each design on a number of aspects described in the preceding section. They were: quality/clarity of the design (overall mean = 2.58), similarity of the design to the negative prime (overall mean = 2.02), likeliness of the cup to tip (overall mean = 2.75), likeness that the cup, if tipped, would spill coffee (overall mean = 2.53), originality (overall mean = 2.71), and practicality (overall mean = 2.41). Inter-rater reliability was examined using Cronbach's Alpha, which was .88 for the quality/clarity of the design, .81 for similarity, .85 for likeliness to tip, .80 for likeliness to spill, .91 for originality, and .82 for practicality.

To check the effectiveness of the time pressure manipulation, the quality/clarity results were analyzed to confirm the presence of the obviously expected effect that time pressure should produce designs that are less clear and easy to read (means = 2.99 with no time pressure and 2.28 under time pressure). This was one way of confirming that participants were, in fact, under time pressure. The effect of time pressure on quality/clarity was, as expected, significant, $F(1, 110)=17.831$, $p < .001$.

Recall that a significant main effect of time pressure on originality and practicality was hypothesized. Those hypotheses were confirmed (see Figures 1 and 2). There was a significant main effect of time pressure on originality (means = 2.82 without time pressure and 2.11 under time pressure), $F(1, 110)= 14.54$, $p < .01$. There was also a significant main effect of time pressure on practicality (means = 2.93 for no time pressure and 2.55 under time pressure), $F(1, 110) = 5.114$, $p < .05$. In addition, the mean score for likeliness to tip was 3.08 without time pressure but dropped to 2.49 under time pressure. That effect was also significant, $F(1, 110)=8.672$, $p < .01$.

Although negative priming did not have significant effects on the originality or practicality of the designs, it can, however, be demonstrated that the negative priming effect was in fact replicated as anticipated. Participants in the negative prime group (mean similarity score = 2.34) were more likely to draw designs similar to the negative prime than participants in those groups that had not seen the negative prime (mean similarity score = 1.72), $F(1, 110) = 12.343$, $p < .01$. In addition, participants in the negative prime group were more likely to draw cups that would tip (mean = 2.95 than those not receiving the negative prime (mean = 2.56), $F(1, 110)=4.387$, $p < .05$. Participants in the negative prime group were also more likely to draw cups that, if tipped, would spill coffee, $F(1, 110)=4.283$, $p < .05$. The fact that the cup would tip was a feature of the negative prime, as was the fact that the cup would spill coffee if it were tipped.

Recall that a significant effect of negative priming on originality (means = 2.43 without negative priming and 2.39 with negative priming) and practicality (means = 2.64 without negative priming and 2.80 with negative priming) had been predicted. The effect

of negative priming on originality was not significant, $F(1, 110)=.001$, $p > .05$. The effect of negative priming on practicality was also not significant, $F(1, 110)=.713$, $p > .05$.

While negative priming alone did not have significant effects on originality or practicality, there was a significant interaction between time pressure and negative priming on originality, $F(1, 110)=4.196$, $p < .05$. There was, however, no significant effect on practicality, $F(1, 110)=.976$, $p > .05$. The interaction demonstrated that, with a negative prime, time pressure had a much more deleterious effect on the originality of the designs (see Figure 1). With no prime, there was only a .3 difference in the originality scores between the time pressure and no time pressure conditions. When a negative prime was added, that difference increased to 1.1. However, the presence of the interaction was verified because, the difference in the negative prime group between time pressure and no time pressure was significant, $t(53)=3.88$, $p < .05$, while the difference between the no negative prime group under time pressure and no time pressure was not significant, $t(57)=1.26$, $p > .05$.

The only other significant interaction was found with the quality/clarity dependent variable, $F(1, 110)=11.759$, $p < .01$. The results indicate that with no time pressure, the designs of the negative prime group are of higher quality, but that when time pressure is added, the quality of the negatively primed designs becomes worse than the quality of designs that did not receive a negative prime (see Figure 3). No other interactions were significant

Discussion

The significant main effects of time pressure on originality and practicality essentially confirm what I suspected: under time pressure, participants will generate less creative cup designs. This is, of course, no surprise, as there is a large body of theoretical evidence demonstrating less creative performance under time pressure in a variety of contexts.

On the negative priming variable, no significant main effects were obtained for originality or practicality. Despite these results, we can be sure that negative priming took place because participants who were negatively primed were more likely to have their designs rated as being similar to the negative prime. In addition, participants who viewed the negative prime were more likely to draw cups that would tip and spill, thus incorporating two important negative features of the prime, considering that the object of the exercise was to draw a spill proof coffee cup (see Appendix 1 for the negative prime).

The reason we can be sure that negative priming had some effect in the absence of a main effect is because of the interaction between negative priming and time pressure on originality (see Figure 1). Without time pressure, the negative prime group was .3 point more original than the no negative prime group. However, with the addition of time pressure, the performance of the negative prime group went from slightly better than the no prime group to much worse, a difference of 1.3 points. Thus, one can argue that the addition of time pressure exacerbates the effects of negative priming.

This finding has particular relevance when one considers the manner in which many real-world high-pressure decisions are made. Many policy and business decisions are made with some amount of unintentional negative priming (i.e. suggestions from advisers, reports and memos, reminders of previous decisions and their consequences)

and under some amount of time pressure. Very rarely outside the laboratory are people told to take all the time they need.

In the course of preparing this experiment, I ran the raters as subjects. They were instructed to think out loud, and they were recorded so that any strategy they were using could be discerned. Under negative priming and without time pressure, the generate idea→check idea→reject/modify strategy was used, and the negative prime was at least partially overcome after several cycles of this, unless the subject looked back too often at the negative prime, in which case he re-primed himself. Thus, the interaction might be a demonstration that, for people who use this generate idea→check idea→reject/modify strategy, time pressure does not allow for it to work.

In addition, both negative priming and time pressure appear likely to encourage people to rely on heuristics (in fact, negative priming itself provides a heuristic) instead of algorithms. For tasks where the algorithm is known, or can be learned, time pressure and negative priming both will decrease the likelihood that it will be used.

There are three possible reasons why, despite the fact that negative priming clearly took place, there were no significant main effects of negative priming on originality or practicality. The first possible reason for the absence of main effects of negative priming has to do with the differences in rating and scoring methodology between Jansson and Smith and the current study, discussed previously in the Method Section. In short, it is possible that instructing raters to rate for subjective things introduced noise into the data, as subjectivity is prone to do. That might have obscured a main effect in a relatively small sample.

The second reason a main effect might not have been observed is that there is no guarantee that all people in the negative prime condition actually looked at the negative prime. The instructions explicitly told them to do so, and the page was pointed out to them, but no provision was made for measuring or regulating how much time they actually spent looking at the negative prime or thinking about the prime before beginning to draw. Given the relatively small sample size, if only a few people didn't look at the prime, or glanced at it for only a second, a significant effect could have been obscured. In the future, I might run this experiment with a computer interface, where the instructions would be displayed onscreen, and the negative prime would remain displayed for a fixed amount of time, forcing participants to actually look at it long enough to think about it.

Related to this, of course, is the possible problem that we have no guarantee that people in the time pressure condition all felt the same amount of pressure, or any pressure at all. Since we know anxiety decreases performance after a certain point (i.e. the Yerkes-Dodson Law), and are also attempting to demonstrate that time pressure decreases performance, those for whom time pressure produces an abnormal additional amount of anxiety will perform even worse on the task than those who felt little or no anxiety under time pressure and simply tried to complete the task. A post-test question about anxiety during the task was administered to the time pressure groups, but would have been helpful in all groups.

On the subject of possible methodological problems, it should be noted that I ran participants in groups for the sake of expediency. This, however, might not have been the wisest idea, as a group effect was observed (but not measured, as it did not seem

relevant at the time), in that once one person completed the task, others in the room would quickly finish. While perhaps an interesting finding for those interested in group dynamics, it is a possible confound in the present study.

The final possible reason for the absence of a main effect of negative priming on originality and practicality is that the definition of creativity used in this study might have been limiting. Recall that originality and practicality were selected as dimensions to be rated because it was felt that they were the two main parts of creativity. A creative solution, I believed, was one that was both original (or novel) and practical. It is probable that there is a third part to this model (such as the ability to actually make the design in real life, or the costs of making one thing over another), which come into play in real life and which would have demonstrated a significant main effect.

One might be tempted to draw from this discussion that negative priming and time pressure have unequivocally deleterious effects. However, the interaction between time pressure and negative priming on quality/clarity demonstrates one of the possible positive effects of negative priming (see Figure 3). Whereas time pressure and negative priming produce designs that are less clear, a negative prime without time pressure will produce designs that are significantly clearer. Thus, it can be safely assumed that negative priming is a good thing under certain circumstances because it gives people a starting point, especially considering that these were introductory psychology students who had never performed a task similar to this. One could imagine, then, an applied setting in which giving examples might be helpful, even knowing that they lead to less creative solutions.

In terms of future research, there are two main implications. One is that this study ought to be run again, using the modifications I suggested which will likely result in stronger effects. Secondly, this study identified and measured only two dimensions of creativity, although there are definitely more that exist. Defining creativity, then, is a lot like defining intelligence in that there are a lot of opinions and possibilities about what to include. A thorough study of other dimensions of creativity, then, would be helpful.

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Figure Caption

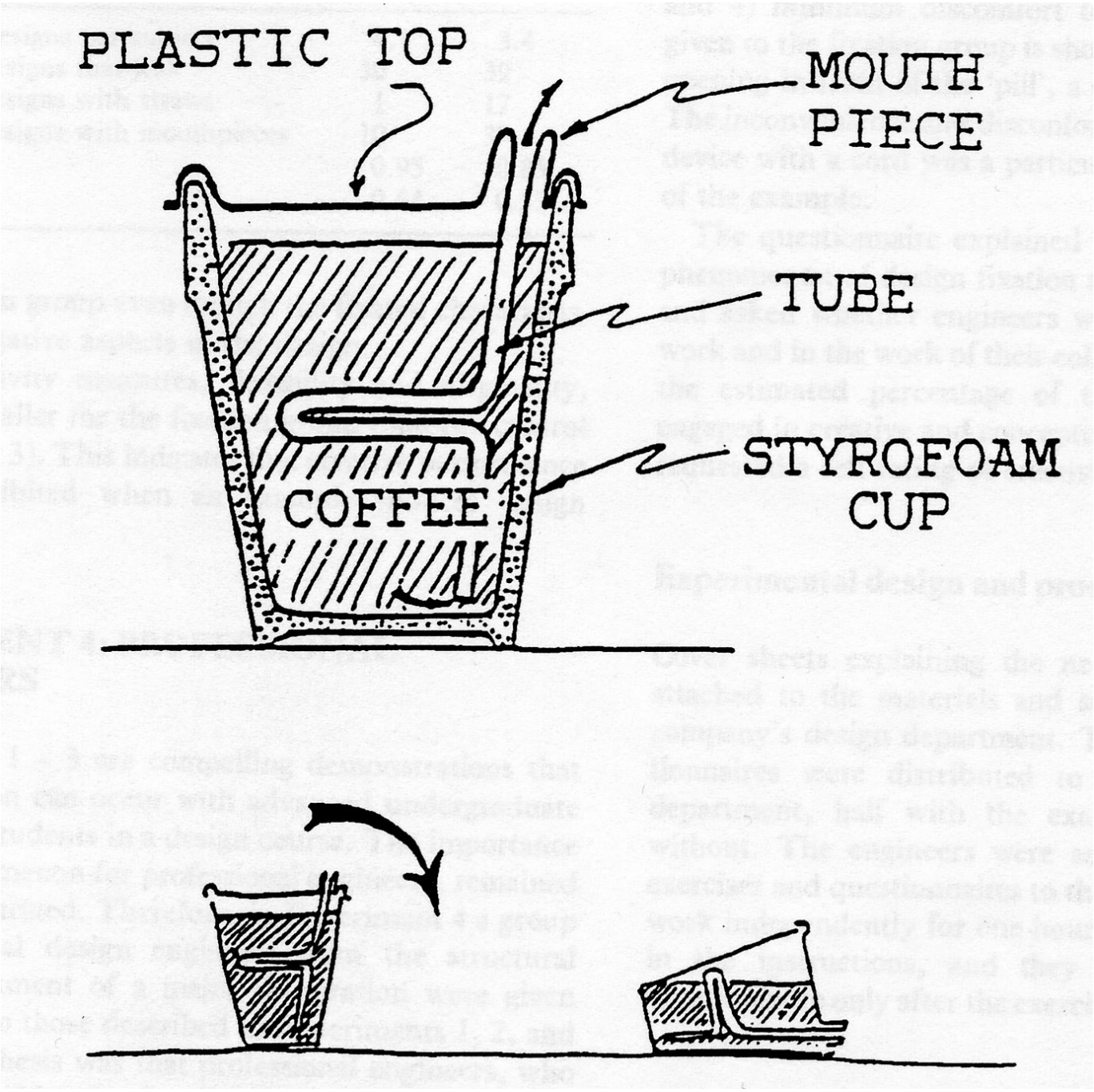
Figure 1. The effect of time pressure on originality scores. The solid line represents the no negative prime condition, while the dashed line represents the negative prime condition. Note the different slopes of the two lines.

Figure 2. The effect of time pressure on practicality scores. The solid line represents the no negative prime condition, while the dashed line represents the negative prime condition. Note the different slopes of the two lines

Figure 3. The effect of time pressure on quality/clarity scores. The solid line represents the no negative prime condition, while the dashed line represents the negative prime condition. Note the different slopes of the two lines

APPENDIX 1

Negative Prime



Appendix 2

Instructions for the Negative Prime/Time Limit Group

Welcome to the experiment!

Your first task will be to draw a spill-proof coffee cup. Follow the detailed instructions below.

- You will have **two minutes** to complete this drawing.
- The object is to construct a spill-proof coffee cup using NO STRAWS, as it is dangerous to drink coffee through a straw.
- This is an experiment designed specifically to have you generate designs other than those that are commonly used. Therefore, you should be as ORIGINAL and PRACTICAL as possible. Your response will be scored for those two aspects.
- Please draw your design from as many angles as possible, and label all parts, to make the interpretation of your design as easy as possible. Be sure to label everything and explain any unusual or innovative features.
- Please draw your design only on the sheet of paper provided in this packet. DO NOT disassemble this packet or use any other reference material. If you need more space, please use the other side of the blank page.
- To further clarify the task, PLEASE SEE THE EXAMPLE SOLUTION ON THE NEXT PAGE.
- Please stop working immediately when the experimenter tells you that time is up, but DO NOT continue on to the next page until instructed to do so by the experimenter.

Appendix 3

Post Experiment Questionnaire for the Negative Prime/Time Limit Group

In your opinion, how ORIGINAL was your coffee cup design? (5 = Most Original)
1 2 3 4 5

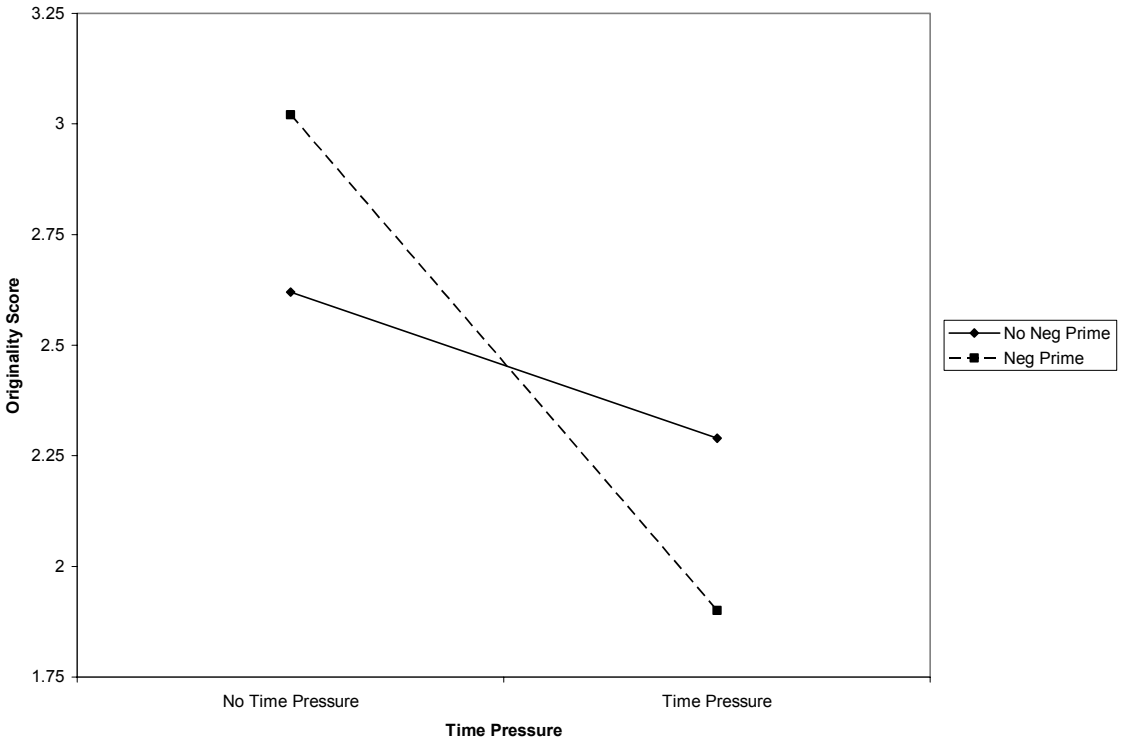
In your opinion, how PRACTICAL was your coffee cup design? (5 = Most Practical)
1 2 3 4 5

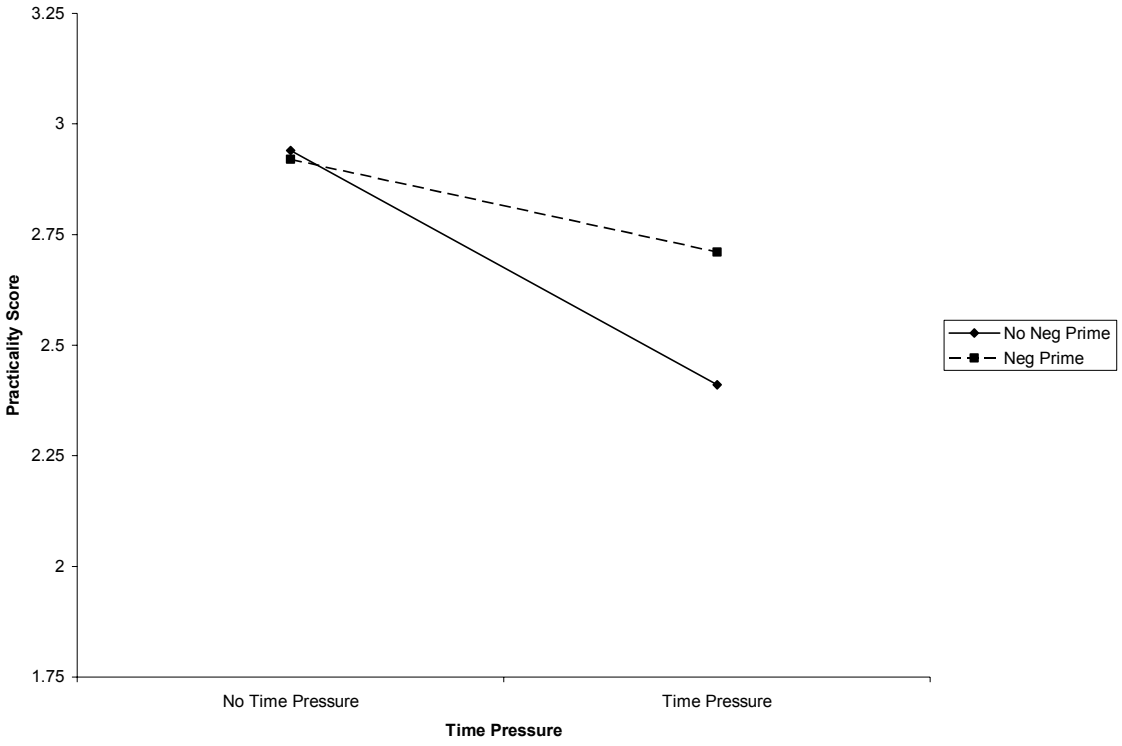
In your opinion, how CREATIVE was your coffee cup design? (5 = Most Creative)
1 2 3 4 5

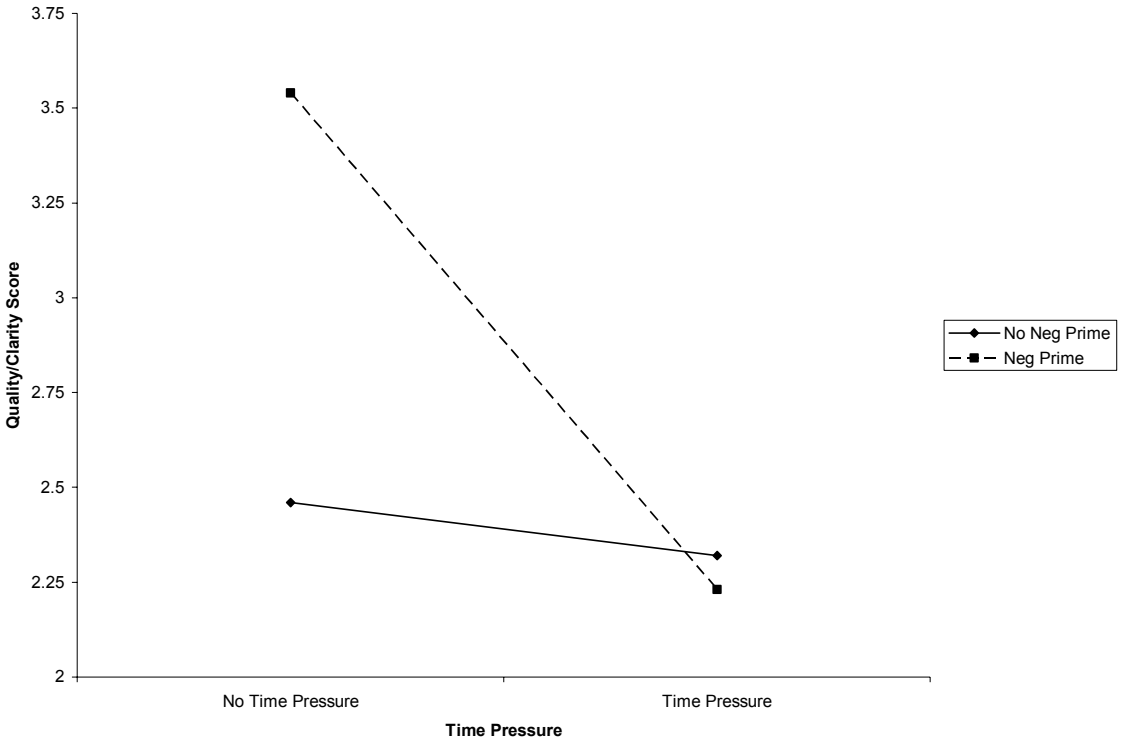
How similar was your design to the example designed provided in this packet?
(5 = Very Similar)
1 2 3 4 5

How anxious did you feel about finishing in the allotted time? (5=Most Anxious)
1 2 3 4 5

Do you feel that you would come up with a better design
if you had more time? (5=Definitely Better)
1 2 3 4 5


3.25
3
2.75
2.5
2.25
2
1.75
Originality Score
No Time Pressure
Time Pressure
Time Pressure
No Neg Prime
Neg Prime


3.25
3
2.75
2.5
2.25
2
1.75
Practicality Score
No Time Pressure
Time Pressure
Time Pressure
No Neg Prime
Neg Prime


3.75
3.5
3.25
3
2.75
2.5
2.25
2
Quality/Clarity Score
No Time Pressure
Time Pressure
Time Pressure
No Neg Prime
Neg Prime