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Running Head: Inhibition and PSS

Abstract

In the process of problem-solving, a limiting of possible solutions often occurs which causes subjects to prematurely narrow their problem-solving options. This tendency is called problem-solving set. It is possible that there is an underlying neurological mechanism which regulates this process. It has been shown that the frontal lobes play a role in the inhibition of irrelevant information, suggesting that they may be involved in the formation of set. Because the frontal lobes are suspected to degenerate somewhat with age, the elderly may have less of a tendency towards problem-solving set than young adults. In the current study, set was induced trough the use of anagrams (tasks which require the subject to unscramble a scrambled word to produce a common word). Young adults were compared to elderly adults. Set-forming anagrams were all solvable by the same strategy, and a "target" anagram (which appeared after the set-forming anagrams) was solvable by a different strategy. The number of set-forming anagrams given was varied, and problem-solving set was measured by comparing latencies between set-forming anagrams and the target anagram. It was found that anagrams are effective at inducing problem-solving set, that the intensity of problem-solving set increases with set size, and that there may indeed be a neurological explanation for age-related differences in the formation of problem-solving set.

Introduction

In problem-solving, it has been found that there may exist a phenomenon called <u>Einstellung</u> or problem-solving set, which is "the habituation to a repeatedly used procedure" (Luchins, 1942, p. 3). This habituation causes perseveration in the learned procedure, even when a simpler solution exists. Luchins pioneered the study of this effect, testing elementary school to college-age students using his water jar problem. The water jar problem consists of the imaginary manipulation of water by pouring it into various jars with set quantities. For example, Luchins used three jars, A, B, and C with the respective capacities of 21, 127, and 3 quarts. Subjects were asked to obtain 100 quarts, which was solvable by the manipulation B - A - 2C. A block of problems, all solvable by this formula, were presented. Following the block was a critical problem that could be solved either with the preceding formula or a much simpler A - C. Luchins found perseverance of set, the solving of the critical problem by the B - A - 2C formula, in 75% of subjects who had previously been warned "Don't be blind" and 100% of subjects who had not been forewarned.

A possible explanation for the perseveration which Luchins found is inhibition. This mechanism relies on an individual's capacity to ignore or inhibit irrelevant information. Thus, in the water-jar problem, the subjects may have been unable to inhibit the previously activated, more complex solution, and they therefore perseverated instead of switching to the simpler solution. Much research in the field of aging has focused on this inhibition-deficit as an explanation for changes in working memory (Hasher & Zachs, 1988), selective attention (Hasher, Stoltzfus, Zachs, & Rypma, 1991), and as a general theory of life span cognitive development (Dempster, 1992). Dempster proposes that this capacity of inhibition is "a major factor in cognitive development and one that is intimately associated with the operation of the frontal cortex of the brain" (p. 46). This claim is supported by both neuropsychological studies with interference-sensitive tasks and studies concerning the development of the frontal lobes.

Subjects with frontal-lobe damage have shown impairment on interference-sensitive tasks, such as the Wisconsin Card Sorting Task (WCST), which requires the ability to overcome a previously correct categorization strategy. On a similar sorting task, subjects with damage to the frontal lobes were found to be "impaired in generating accurate sorts, deficient in identifying sorting rules, and exhibiting abnormal perseveration of sorts and rule names" (Delis, Squire, Bihrle, & Massman, 1992, p. 690). Stuss and Benson (1984) report perseverative behavior "in diverse tasks including motor acts, verbalizations, sorting tests, drawings, writing, and tracking tests" in their frontal lobe subjects (p. 13).

Similar perseverative behavior has been seen in the elderly. Davis et al., (1990) found the elderly to make significantly fewer set changes and more perseveratory errors on the WCST, and Daigneault, Braun, & Whitaker (1992) found significantly greater perseveration by 45-65 year-old subjects than 20-35 year-old subjects on four prefrontal measures. These results would indicate that, with age, there may be a decline in frontal lobe functioning.

It is, in fact, believed that the frontal lobes are the first to deteriorate as individuals age. Furthermore, "it is quite tempting to suggest that one of the developmental characteristics of this [frontal lobe] brain function is 'last to appear, first to disappear'"(Wang, 1987, p. 197-198). Dempster (1992) cites much evidence to suggest "a decrease in the size, volume, and density of cells. . . . significant declines in brain weight and cortical thickness in the frontal region. . . . shrinkage of large neurons and shrinkage and disappearance of horizontal dendrites which are thought to have inhibitory properties. . . . declines in cerebral blood flow," all concurrent with the aging process (p. 50). This frontal lobe deterioration as well as the aforementioned neuropsychological studies are Dempster's basis for the belief that inhibitory processes are housed in the frontal lobes. (for further discussion, see Dempster (1992), p. 49-51)

If the elderly have deficiencies in inhibitory mechanisms because of frontal lobe deterioration, their ability to form problem-solving set (which requires inhibition) may be affected. Using Luchins' water jar problem, Ransopher and Thompson (1991) tested both young and old subjects on Luchins' water-jar problem. They used three set sizes, which included 1, 5, and 10 set-inducing problems. They labeled five problems following the set as the criticals. These were solvable by both the previous solution rule and a simpler rule. The next problem, the extinction problem, was solvable only by the simpler rule. The main effect for set size, the number of set-inducing problems in a block, was significant, but the main effect of age was not. It was found that subjects were more likely to solve the problem by the simpler rule on the extinction task than the criticals. However, this result is not surprising since the problem had only one solution, the simpler rule. It is possible that the subjects took longer to solve this problem since time, limited to five minutes per problem, was not markedly restrictive. Five minutes should have been sufficient for most to find the one possible solution.

Despite the findings of Ransopher & Thompson (1991), the aging literature still seems to suggest an age-related difference in the formation of problem-solving set. In trying to demonstrate problem-solving set, researchers in the past have assumed that the effects of age could be seen in the number of errors made by subjects (Luchins, 1942; Ransopher and Thompson, 1991). It would seem that, in complying with the inhibition-deficit hypothesis, testing latency would be both more appropriate and more sensitive to the effects of Einstellung, since the elderly would suffer impairment to inhibition not the complete loss of inhibition. The use of problems which contain more than one solution rule, like the criticals in the water jar problem, is not compatible with the testing of latency, since perseveration in set would produce no greater latency on the criticals. Therefore the critical problem must be of a different solution rule than the set-inducers and have but a single solution.

The aforementioned problems, the water jar problem and the sorting tasks, are both implicit memory tasks. Implicit memory tasks are those which do not rely on conscious memory, rather experience. There has been support for the classification of anagrams as tests of implicit memory as well (Java, 1992; Srinivas and Roediger, 1990). Anagrams tasks are those that ask the subject to unscramble letter strings to form a word. Little research has been done on the use of anagrams to study problem-solving set, but they could be instrumental in showing this phenomenon, as they could allow the simple examination of entrance into and exit from set. The influence of problem-solving set on anagram tasks will be studied in college-age and elderly subjects because of their varying levels of frontal lobe functioning. The use of the inhibition-deficit hypothesis as an explanation for problem-solving set has not yet been studied. This union could provide a neuropsychological explanation for the effect of problem-solving set.

Hasher and Zachs (1988) suggest that a disruption of inhibition in the elderly decreases the ability to "limit entrance into working memory to information which is along the 'goal path' of comprehension" (p. 212). This suggests that irrelevant information is allowed into working memory and causing interference and ultimately inadequate registration of the relevant information. It is also possible that inhibition deficits are exhibited at the retrieval of information. Were an individual unable to inhibit a previously correct method of solution, perseveration would result. The lack of knowledge about the inhibition mechanism leaves us with two different hypotheses. Hypothesis 1 is that the loss of inhibition in the elderly causes inadequate registration and weaker problem-solving set, as the set is built on the narrowing of possible answers until a definite solution rule is established. This weak set would be more easily broken, and the elderly subjects may be faster at solving the critical problem. Secondly, the elderly may instead enter set like the younger subjects, but have trouble breaking the set because they will have difficulty inhibiting the previous solution rule. This hypothesis predicts a slower solving of the critical problem. Both of these hypotheses are based on the assumption that the young subjects will have a greater level of frontal lobe functioning than the older subjects. Regardless of which hypothesis was supported, in accordance with the study of Ransopher and

Thompson (1991), it was hypothesized that there would be a significant interaction of set size and trial type. This suggests that the strength of problem solving set may increase as the set size increases.

Method

Subjects

There were twenty-one subjects in this study. The "Young" group consisted of eleven undergraduate students with a mean age of 20.0 years, obtained from introductory psychology classes for the incentive of extra-credit. The "Elderly" group consisted of ten adults, age 65 or over with a mean age of 83.3, recruited through retirement communities and advertisements. These subjects had no past history of brain damage, as indicated from a background data questionnaire. Their current medications included only those for the control of blood pressure, diabetes, and a thyroid condition. The elderly subjects were paid $10 for their participation. All subjects were given the Kaufman Brief Intelligence Test (KBIT) to assure that they were of a similar ability level. The young subjects had a mean KBIT score of 112.3, and the elderly had a mean score of 116.9. The elderly subjects were slightly more educated, with a mean of 14.5 years of formal education as compared to the young subjects' 13.6 years.

Materials

Subjects were given an anagram test on a Macintosh Centris 610 computer or a Macintosh Powerbook 170, both equipped with a voice-activated timer. The anagrams were four-letter nouns presented individually in large letters, centered on the screen. They had only one possible solution. The solution rules (order of scrambling) were manipulated. Each test included twelve blocks of problems, each block having a different solution rule. The anagrams within the block were the non-target anagrams. The set sizes were set at 6, 9, 12, and 15, so that the number of problems necessary to elicit problem-solving set could be observed. Following each block was a target problem having a different solution rule, whose latency was compared to the mean latency of the preceding block. Following each target were 0, 1, or 2 filler anagrams with different solution rules which served to break the established pattern. There were 150 anagrams in all. Each anagram was presented until the subject made a response, or for two minutes, whichever occurred first.

Procedure

Subjects were led to a quiet room, either a laboratory, or in the case of the elderly subjects, a room of their home. Consent and background data forms were completed, and then the KBIT was administered. Subjects were next given instructions as to the nature of the test. They were asked to work as quickly and accurately as possible, as their work was to be timed. Ten practice anagrams were given, and were repeated if the subject so desired. When the subject felt comfortable, the experiment began.

When unscrambling the anagrams, the subject remained silent until the problem was solved, and then answered in a voice sufficiently loud to be recognized by the computer. Upon detecting a response, the computer paused for 3 seconds and then presented the next anagram. If the subject did not provide an answer within 2 minutes, the anagram disappeared and the next one appeared. The researcher was present to record any incorrect answers or trials in which the computer recorded extraneous noise as a response. The time between the appearance of the anagram and the subject's response was recorded. Following the test, the subjects were thoroughly debriefed. The complete testing lasted approximately one hour.

Results

A 2 X 2 X 4 analysis of variance (subject group X set size X trial type) was performed on the latency difference score, the difference between the mean latency of the block and the following critical problem. Trials for which the subject did not provide an answer within two minutes, for which the answer was incorrect, or for which the computer was falsely activated, were eliminated. Anagrams were found to be effective at inducing problem solving set, since the target anagrams took significantly longer to solve than the noncritical anagrams, $F(1, 2652) = 7.244$, $p<.01$. As predicted, an interaction of set size and trial type was seen, $F(3,2652) = 6.135$, $p<.01$, supporting the results of Ransopher and Thompson (1991). As shown by Figure 1, this interaction demonstrates that overall strength of set, or positive increase between latency of non-target and target anagrams, increases as the size of set increases.

Insert Figure 1 about here

Significant effects were also found for set size, $F(3, 2652) = 2.706$, $p<.05$, and the interaction of group and set size, $F(3, 2652) = 2.734$, $p<.05$. A three-way interaction showed a very significant effect of group X sef size X trial type, $F(3, 2652)$, $p = .0047$.

However, the trends shown at the varying set sizes were not able to produce a standard curve. At a set size of 6, no effect of problem-solving set was shown. At a set size of 9, elderly subjects exhibited problem-solving set, while undergraduatés did not. At a set size of 12, undergraduates exhibited considerable problem-solving set while the elderly showed none. Both groups showed comparable set at a size of 15 (see Figure 2).

Insert Figure 2 about here

Discussion

Because of the lack of knowledge about the exact nature of the inhibitory process, we proposed two alternative hypotheses. Hypothesis 1 predicted that a loss of inhibition due to deterioration of the frontal lobes would cause a weak problem-solving set which would easily be broken. Hypothesis 2 predicted that this loss of inhibition would cause difficulties in breaking an already established set. In addition, we hypothesized that there would be a significant interaction of set size and trial type. Support for either of the alternative hypotheses would support a role of the frontal lobes in inhibition, and a possible neuropsychological explanation for problem-solving set.

The results of this study provide three main findings. First, anagrams can be effectively used to induce problem-solving set. This was shown by a significant effect of trial type, that is, target anagrams took significantly longer to solve than non-targets. Secondly, we were able to replicate the finding of Ransopher and Thompson (1991) that the intensity of problem-solving set increases as set size increases. In other words, the more set-inducing problems a subject is given, the more difficult it becomes for him/her to break set. These results demonstrated this effect not by correctness of response, rather by latency. Lastly, these results are inconclusive in supporting either of the inhibition-based hypotheses. From Figure 2, we can deduce that 6 anagrams were not enough to induce problem-solving set in any of our subjects, and 15 anagrams were enough to produce similar levels of set in both groups. The results at set sizes of 9 and 12 are not so conclusive.

The results of set size 9 show that the elderly entered into problem-solving set while the undergraduates did not. This is somewhat consistent with our second hypothesis, that the elderly will show more perseverative behavior because they lack the inhibition necessary to move on to a new solution rule. However, at a set size of 12, undergraduates showed problem-solving set while the elderly subjects did not. This lends support to the first hypothesis, that because of a lack of inhibition at encoding, elderly subjects have too much interference from irrelevant information to form effective problem-solving set. There are several possible explanations for these inconclusive findings.

It is possible that the lack of complete randomization in this study left extraneous variables, such as effect of word, to conceal the true results. It is also possible that there is some sort of strategy shift between set sizes of 9 and 12 which is different across age groups. To make these results more conclusive, further studies need to be completely randomized and examine the effect of problem-solving set at more set sizes.

The problem of randomization in this study brings into question the internal validity of this study. However, in many other ways the internal validity was controlled for well. For instance, all subjects scored similarly on measures of intelligence, and all subjects were tested on reliably similar equipment. Although the elderly subjects were not tested in a laboratory environment, the effects of this difference are minute and should not be considered a threat. Though the sample sizes were small, the results of this study still provide an important look into the formation of problem-solving set.

This study provided firm support for the use of anagrams as a means for inducing problem-solving set, and for a measurable intensity of set. But the inconclusive results at set sizes 9 and 12 should not be disregarded. The mere fact that differences were seen between the groups at these sizes supports the notion that the decrease in frontal lobe functioning with age could play a role in the formation of problem-solving set. These results are ones which should definitely be investigated further. It is possible that including several age groups in this study could demonstrate the development of the frontal lobes from childhood to old age, and the influence of this development on an important but little understood phenomena.

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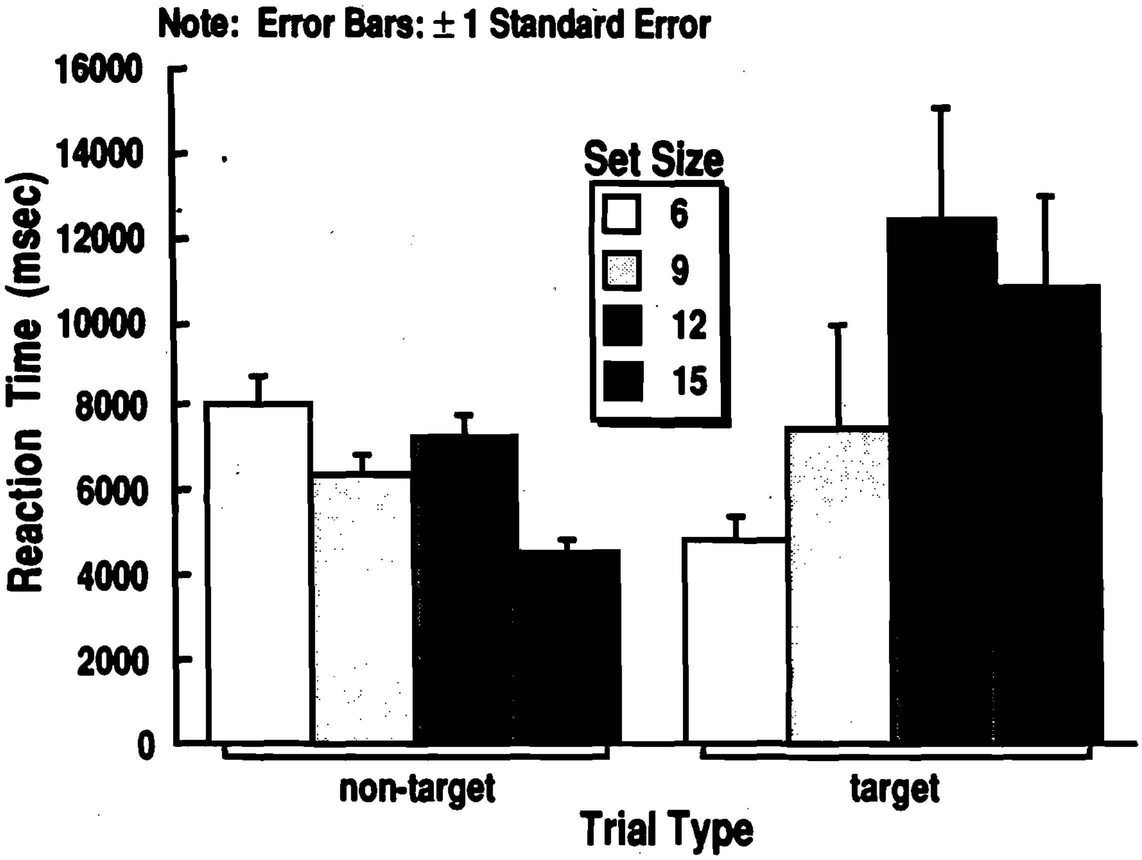
Figure Caption

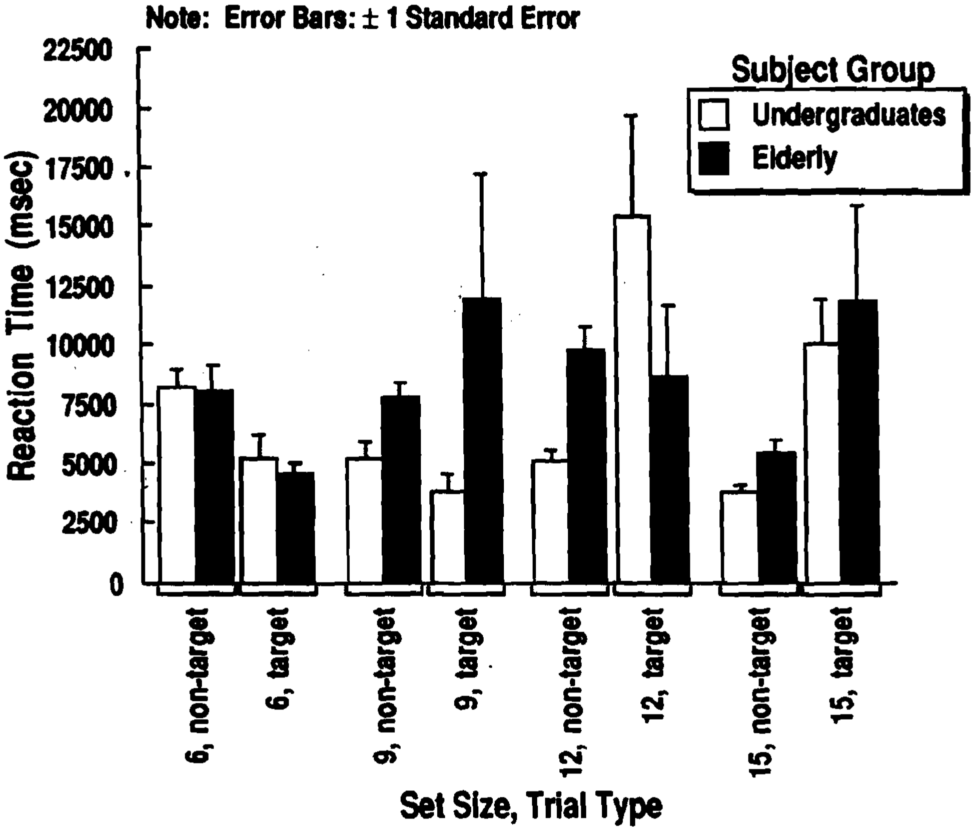
Figure 1. Interaction of trial type X set size.



Note: Error Bars: ± 1 Standard Error
16000
14000
12000
10000
8000
6000
4000
2000
0
Reaction Time (msec)
Set Size
6
9
12
15
non-target
target
Trial Type

Figure Caption

Figure 2. Interaction of trial type X set size X subject group.



Note: Error Bars: ± 1 Standard Error
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
Reaction Time (msec)
Subject Group
Undergraduates
Elderly
6, non-target
6, target
9, non-target
9, target
12, non-target
12, target
15, non-target
15, target
Set Size, Trial Type