

## PRODUCTION OF NEGATIVE TRANSFER IN A PROBLEM-SOLVING TASK<sup>1</sup>

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*Summary.*—72 students solved two problems using a source problem designed to inhibit performance on the target problem relative to baseline performance when the target problem was solved alone. Both source and target problems shared surface similarity but were structurally dissimilar. Negative transfer was found for three different source and target combinations. The decreased performance below baseline for three of the source-target programs provides a reliable context to demonstrate negative transfer and facilitate continued investigation of this phenomenon.

A review of the literature using the term negative transfer highlights the versatility and potential confusion of this phrase in psychology. Depending on the topic of study, negative transfer could refer to a form of inhibition in conditioning studies (Randall, Goodman, & Dickinson, 1998; Lachnit & Kinder, 2000), the depiction of negative transfer as a form of cognitive confusion (Blais, Kerr, & Hughes, 1993; Zalstein-Orda & Lubow, 1995), memory interference with regard to the recall of word lists (Tulving & Watkins, 1974; Robbins & Irvin, 1976), or even how negative transfer threatens flying safety (Rayman, 1982). For the purposes of this problem-solving study, negative transfer is demonstrated by the detrimental effect of a prior experience on present performance. This definition is similar to those of Holding (1976, 1987) and Gick and Holyoak (1987). The study of positive transfer in a variety of domains has received more attention than the study of negative transfer. The study of positive transfer (which is the beneficial effect of a prior experience on present performance) has been studied widely in the problem-solving literature, including the study of analogical transfer between problem sets (Gick & Holyoak, 1980; Holyoak & Koh, 1987; Novick, 1988, 1990; Niedleman, 1991).

In problem-solving studies, when different problems are used to assess positive transfer from one problem to another, both surface and structural similarity play important roles (Holyoak & Koh, 1987). Problems that share surface similarity look the same; they may have the same sentence structure or concern the same genre of problem to be solved. Problems that are struc-

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turally similar require the same problem-solving tactics. Note that problems can be similar on the surface but be structurally dissimilar; that is, the wording of the problem makes them appear to be slight variations of the same problem, but the strategies for solving are quite different. Also, problems can be dissimilar on the surface but structurally similar; two problems can look completely different yet the same problem-solving approach solves both problems.

There are relatively few examples of negative transfer in problem-solving. The Luchins (1942, 1946) water-jug problem is a good example of how problems appear to be similar on the surface but are structurally different. Thus, success on solving earlier water-jug problems impedes progress on solving later problems that look the same but can be solved with much simpler solutions (the *Einstellung* effect). Lewis, McAllister, and Adams (1951), in a study of complex motor skill learning, found that, when the motor controls were reversed on a complex task, significant negative transfer occurred (see also Schmidt & Young, 1987). Understanding negative transfer and the conditions under which it occurs has important implications. In training or education, negative transfer would indicate the later task performance or problem-solving would be lower given previous experience, which is not the typical learning outcome desired.

The goal of this study is to create a set of problem-solving tasks that can reliably produce negative transfer. Comparing performance on the target problem to baseline rates previously established, different source problems were used prior to the presentation of the target problem to see whether performance on the target problem was decreased significantly below the expected baseline rate. Establishing a problem set that can reliably demonstrate negative transfer would facilitate studies of the variables which affect the transfer process. To go beyond textbook definitions of problem-solving processes, experimental stimuli must be available to test these hypotheses. This can be approached from a number of perspectives, but the approach taken in this study was to develop problem sets that on the surface seemed similar, whereas the required problem-solving tactics were actually dissimilar. This underlying dissimilarity was the potential source of the negative transfer. To test this hypothesis, however, one has to have experimental stimuli which produce negative transfer before the variables influencing negative transfer can be systematically studied. This study provides three such problem pairs.

#### METHOD

##### *Participants*

Seventy-two students enrolled in an introductory psychology course at a large western university in the United States participated for course credit.

To assure anonymity, no identifying information (age, sex, ethnicity) was collected from participants. Unfortunately, given this anonymity, it is not known whether the present sample is similar to samples tested in previous work.

### Materials

The six target problems and the 12 source problems in this study are presented in Table 1. The six target problems had been used in previous normative studies (Middleton, Ozimkiewicz, & Landrum, 1995) with  $N_s > 200$ ; thus, the baseline rate for solving the target problems without any source problem was known. The baseline performance for each target problem is presented in Table 2 below. Although each participant only received one source problem and one target problem, the two source problems for each target were similar, both on the surface and structurally.

TABLE 1  
SOURCE AND TARGET PROBLEMS USED FOR NEGATIVE TRANSFER

Lunch Problem	
Source 1.	Next week I am going to have lunch with my father, visit the library, go to the income tax office, and have my teeth cleaned at the dentist. My father cannot meet me on Monday; the income tax office is closed Tuesday and weekends; the dentist office is only open Wednesday; the Library is closed Thursday, Friday, and weekends. What day can I do everything I have planned?
Source 2.	Next week I am going to have lunch with my cousin from Ohio; we are going to visit the park and go to the museum and the zoo. My cousin will only be here Friday and Saturday; the park closes at sunset; the museum is only open Monday through Friday; the zoo is open Tuesday through Saturday. What day can we do everything we have planned?
Target:	Next week I am going to have lunch with my friend, visit the new art gallery, go to the Social Security office, and have my teeth checked at the dentist. My friend cannot meet me on Wednesday; the Social Security office is closed weekends; the dentist has office hours only on Tuesday, Friday, and Saturday; the art gallery is closed Tuesday, Thursday and weekends. What day can I do everything I have planned?
Stamps Problem	
Source 1.	How many stamps are there in a dozen?
Source 2.	How many stamps are there in 10 dozen?
Target:	How many three cent stamps are there in four dozen?
Corn Problem	
Source 1.	Bob and Sandy own a nice home with a pool in the back yard which measures 60 feet by 100 feet. They would like to swim laps in the pool, and they each plan to swim 900 yards per day. Bob and Sandy are arguing about the number of laps they will have to swim. Bob says they will have to swim 300 laps, while Sandy says they will have to swim 27 laps. Who is right, and why?
Source 2.	Bob and Sandy own a nice home with a garden in the back yard which measures 8 feet by 10 feet. They would like to plant some corn in the garden, and the seed packet said it was best to plant the corn in 3 rows, each row extending 10 feet. Bob and Sandy are arguing whether or not they can plant the corn. Bob says you can't plant 3 rows in an 8 x 10 foot plot, while Sandy says you can. Who is right and why?
Target:	Bob and Sandy own a nice home with a garden in the back yard which measures 8 feet by 10 feet. They would like to plant some corn in the garden, and the seed packet said it was best to plant the corn in 2 rows, each extending 12 feet. Bob and Sandy are arguing whether or not they can plant the corn. Bob says you can't plant a row longer than 10 ft. in an 8 x 10 foot plot, while Sandy says you can. Who is right, and why?
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TABLE 1 (CONT'D)  
SOURCE AND TARGET PROBLEMS USED FOR NEGATIVE TRANSFER

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Socks Problem	
Source 1.	If you have 10 black socks and 8 brown socks mixed in your drawer, how many matched pairs can you make?
Source 2.	If you have 26 black socks, 72 red socks, and 4 green socks in your drawer, how many socks do you have?
Target:	If you have black socks and brown socks in your drawer, mixed in a ratio of 4 to 5, how many socks will you have to take out to make sure that you have a pair the same color?
Medicine Problem	
Source 1.	You have a problem taking your medicine. The doctor tells you to drink exactly 4 ounces, but you have a 1-ounce container. How can you determine the right amount?
Source 2.	You have a problem taking your medicine. The doctor tells you to drink exactly 4 ounces, but you have a 2-ounce container. How can you determine the right amount?
Target:	You have a problem taking your medicine. The doctor tells you to drink exactly 4 ounces, but you have a 5-ounce and a 3-ounce container. How can you determine the right amount?
Team Problem	
Source 1.	There are six men on a hockey team. How many periods are there in a game?
Source 2.	There are eleven men on a football team. How many quarters are there in a half?
Target:	There are nine men on a baseball team. How many outs are there in an inning?

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### *Procedure*

Participants were tested in groups. Each received a packet with one source problem and one target problem. Given six possible target problems and two possible sources for each target, there were 12 possible combinations (Source 1 Lunch problem, Target Lunch problem; Source 2 Lunch problem, Target Lunch problem; Source 1 Stamps problem, Target Stamps problem; Source 2 Stamps problem, Target Stamps problem, etc.)—these are presented in Table 2 below. Six students completed each of the 12 possible combinations of source and target problems. Participants were given 2.5 min. to solve each problem. For each combination of source and target, the problems were designed to be similar on the surface but structurally dissimilar.

### RESULTS AND DISCUSSION

Performance on the target problem using Source 1 or Source 2 was compared against baseline performance on that problem using a test for significance differences between two proportions (Bruning & Kintz, 1977). This analysis yielded a  $z$  score statistic, with  $z$  scores  $> 1.96$  indicating a significant difference between the proportions ( $p < .05$ ). Results of all the analyses are presented in Table 2. There were three combinations with statistically significant negative transfer. When the Source 2 Lunch problem preceded the Target Lunch problem (baseline = 81% correct), performance on the target problem was reduced to 61.1% correct. When the Source 2 Corn problem preceded the Target Corn problem (baseline = 48% correct), performance on

TABLE 2  
PROPORTIONS CORRECT AND *z* SCORES FOR SOURCE-TARGET PROBLEM PAIRS (*N* = 72)

Problem Set	Target Problem†		Baseline Performance (%)	<i>z</i>
	Source	%		
Lunch	1	72.2	81	0.89
	2	61.1		
Stamps	1	94.0	66	2.44*
	2	72.0		
Corn	1	50.0	48	0.16
	2	16.6		
Socks	1	27.7	31	0.29
	2	5.5		
Medicine	1	27.0	22	0.48
	2	5.0		
Teams	1	61.0	60	0.08
	2	66.6		

Note.—Each source-target combination was solved by 6 participants. For significance, *z* scores > 1.96 are considered statistically significant. †Performance when using this source. \**p* < .05.

the target problem was reduced to 16.6% correct. And, when the Source 2 Socks problem preceded the Target Socks problem (baseline = 31% correct), performance on the target problem was reduced to 5.0% correct. These three pairings of problems produced negative transfer out of the 12 overall combinations.

There was also one example of positive transfer in this study. When the Source 1 Stamps problem preceded the Target Stamps problem (baseline = 66%), target problem performance improved to 94.0% correct. This unexpected finding points to the value of having both normative data available and for the availability of known problem pairs on which negative transfer can be observed. In this particular problem pairing, significant positive transfer occurred. With the availability of problem pairs known to produce negative transfer, researchers can now explore what additional variables influence the magnitude of negative transfer. This may lead to work concerning the extent of surface and structural similarity (e.g., Holyoak & Koh, 1987), the consideration of floor and ceiling effects in problem-solving, and numerous other variables. For instance, can the magnitude of the negative transfer effect be manipulated? Once negative transfer effects are identified, what steps must be taken to ameliorate their effects?

Whereas negative transfer has a long history, that history has not yielded voluminous information. It is hoped that by providing a set of stimuli that reliably show negative transfer, research into understanding its origins and context for occurrence might be better understood.

#### REFERENCES

- BLAIS, C., KERR, R., & HUGHES, K. (1993) Negative transfer or cognitive confusion. *Human Performance*, 6, 197-206.

- BRUNING, J. L., & KINTZ, B. L. (1977) *Computational handbook of statistics*. (2nd ed.) Glenview, IL: Scott, Foresman.
- GICK, M. L., & HOLYOAK, K. J. (1980) Analogical problem solving. *Cognitive Psychology*, 12, 306-355.
- GICK, M. L., & HOLYOAK, K. J. (1987) The cognitive basis of knowledge transfer. In S. M. Cormier & J. D. Hagman (Eds.), *Transfer of learning: contemporary research and applications*. San Diego, CA: Academic Press. Pp. 9-46.
- HOLDING, D. H. (1976) An approximate transfer surface. *Journal of Motor Behavior*, 8, 1-9.
- HOLDING, D. H. (1987) Concepts of training. In G. Salvendy (Ed.), *Handbook of human factors*. New York: Wiley. Pp. 939-962.
- HOLYOAK, K. J., & KOH, K. (1987) Surface and structural similarity in analogical transfer. *Memory & Cognition*, 15, 332-340.
- LACHNIT, H., & KINDER, A. (2000) Stimulus representations in human Pavlovian conditioning: implications of missing negative transfer across response systems. *Quarterly Journal of Experimental Psychology*, 53B, 209-224.
- LEWIS, D., McALLISTER, D. E., & ADAMS, J. A. (1951) Facilitation and interference in performance on the modified Mashburn apparatus: I. The effects of varying the amount of original learning. *Journal of Experimental Psychology*, 41, 247-260.
- LUCHINS, A. R. (1942) Mechanization in problem solving. *Psychological Monographs*, 54, No. 6. (Whole No. 248).
- LUCHINS, A. R. (1946) Classroom experiments on mental set. *American Journal of Psychology*, 59, 295-298.
- MIDDLETON, T., OZIMKIEWICZ, S., & LANDRUM, R. E. (1995) Negative transfer in problem solving: a normative study. Presented at the May Midwestern Psychological Association, Chicago, IL.
- NIEDELMAN, M. (1991) Problem solving and transfer. *Journal of Learning Disabilities*, 24, 322-329.
- NOVICK, L. R. (1988) Analogical transfer, problem similarity, and expertise. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 510-520.
- NOVICK, L. R. (1990) Representational transfer in problem solving. *Psychological Science*, 1, 128-132.
- RANDALL, W. E., GOODMAN, D., & DICKINSON, J. (1998) One-trial learning: predictions about negative transfer. *Psychological Reports*, 82, 795-802.
- RAYMAN, R. B. (1982) Negative transfer: a threat to flying safety. *Aviation, Space, & Environmental Medicine*, 53, 1224-1226.
- ROBBINS, D., & IRVIN, J. R. (1976) The priority effect: test effects on negative transfer and control lists. *Bulletin of the Psychonomic Society*, 8, 167-168.
- SCHMIDT, R. A., & YOUNG, D. E. (1987) Transfer of movement control in motor skill learning. In S. M. Cormier & J. D. Hagman (Eds.), *Transfer of learning: contemporary research and applications*. San Diego, CA: Academic Press. Pp. 47-79.
- TULVING, E., & WATKINS, M. J. (1974) On negative transfer: effects of testing on list on the recall of another. *Journal of Verbal Learning and Verbal Behavior*, 13, 181-193.
- ZALSTEIN-ORDA, N., & LUBOW, R. E. (1995) Context control of negative transfer induced by preexposure to irrelevant stimuli: latent inhibition in humans. *Learning & Motivation*, 26, 11-28.

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