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Visual–Spatial abilities and goal effect on strategies used to solve a block design task

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ABSTRACT

In this experiment we studied the effect of goal setting on the strategies used to perform a block design task called Samuel. Samuel can measure many indicators, which are then combined to determine the strategies used by participants when solving Samuel problems. Two experimental groups were set up: one group was given an explicit, difficult goal; the other was not given a goal. The two groups were comparable in their average visual–spatial abilities. The results indicated that the goal had an effect on the cognitive strategies used. The participants with a goal had a higher anticipation index, which is strongly linked to visual–spatial abilities. This beneficial effect of a specific, difficult goal occurred regardless of the participants' initial visual–spatial abilities, that is, anticipation was greater in the groups with a goal, whether they had good or poor visual–spatial abilities. However, insofar as the model-viewing frequency was higher in the goal group, the goal did not have an effect on synthetic-strategy use, which was the most strongly correlated with visual–spatial abilities.

1. Framework

The purpose of the present study, conducted in the framework of goal-setting theory (Latham & Locke, 2007), was to assess how goals affect performance and strategies on intelligence tests. Taking a goal-setting perspective, many studies have shown that performance enhancement depends on both the strategies available for the task (Seijts & Latham, 2005) and the participants' cognitive abilities (Seijts, 2009). Here, we used a computerized tool to study performance and strategies on Kohs Block Design Task (Rozencwajg & Corroyer, 2002), a task that is tightly linked to visual–spatial abilities. The original Kohs Block Design Task was published by Kohs in 1920 (Kohs, 1920).

1.1. Goal-setting theory

1.1.1. Assigning a goal and directing attention

For several decades, the goal-setting paradigm has provided a framework for explaining the effect of motivation on performance. Many studies have shown that assigning participants a goal that is both specific and difficult leads to better performance than a vague goal such as “Do your best” (Latham & Locke, 2007; Locke & Latham, 1990; Locke & Latham, 2002), where a specific goal is one that clearly states what level of performance the participant should strive to attain. According to Locke and Latham (2002), “This is because do-your-best goals have no external referent and thus are defined idiosyncratically. This allows for a wide range of acceptable performance levels, which is not the case when a goal level is specified” (p. 706). Indeed, specifying the performance level to be attained will attract the participant's attention to the task aspects most relevant to the specified goal. Locke and Bryan (1969), for example, who used an automobile-driving task with multiple feedbacks about various aspects of the task, showed that performance increased only on dimensions related to the assigned goal. A specific goal alone, however, is not enough to lead to higher performance. The goal must also be difficult (for a review, see Latham & Locke, 2007, and Locke & Latham, 2002). A difficult goal is one that only a small number of individuals can attain. In a text-learning task, Laporte and Nath (1976) showed that a specific but easy goal (attained by 80% of the participants in the do-your-best group) did not give rise to better results than a vague, do-your-best goal. On the other hand a specific, difficult goal (attained by 10% of the participants in the do-your-best group) significantly improved performance as compared to a vague goal or a specific, easy goal.

Locke and Latham (2002) explained the positive effect of a specific, difficult goal on performance not only in terms of attention but also in terms of effort. In an experiment by Rothkopf and Billington (1979), subjects spent more time studying texts when they had such a goal. Similarly, in Rozencwajg and Fenouillet's (2012) study using a visual–spatial construction task, participants were able to reach the goal by maintaining a high level of effort throughout task execution.

1.1.2. Importance of strategies and cognitive abilities with a goal

But simply allocating more effort may not always suffice because participants also need to have an adequate strategy for carrying out

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the task. Such strategies are available for the computerized Kohs Block Design Task (Samuel), except in cases of low intelligence (Rozencwajg, Aliamer, & Ombredanne, 2009).

Another modulator of the goal effect on performance is cognitive abilities. According to Kanfer and Ackerman (1989), individuals who have lower cognitive abilities (measured by a cognitive test with the general, perceptual, and speed factors) must exert more effort than individuals with high cognitive abilities in order to concentrate on the activity and reach the goal. For these individuals, a specific, difficult goal increases the amount of effort and directs attention to relevant aspects of the task. By contrast, individuals with high cognitive abilities automatically allocate more effort and are thus in lesser need of a goal aimed at increasing their effort level or directing their attention to relevant task elements.

As in a number of other studies (Kanfer & Ackerman, 1989; Latham, Seijts, & Crim, 2008; Seijts & Crim, 2009), our previous study using a block design task called Samuel (Rozencwajg & Fenouillet, 2012) found that setting a specific, difficult goal was the most beneficial to individuals with poor visual–spatial abilities. By means of various indexes, we were able to show that a specific, difficult goal allowed individuals with low visual–spatial abilities to improve certain strategical aspects of their problem-solving behavior and also to concentrate more. However, to reach the goal set for them, these participants did not modify their cognitive strategies in a fundamental way but only changed certain peripheral aspects. In short, the time allotted to subjects with lesser visual–spatial abilities allowed them to attain the goal without necessarily using the most efficient strategies for this type of task. Studies on Samuel have shown that the most effective problem-solving strategies are used mainly by individuals with high visual–spatial abilities (Rozencwajg, Cherfi, Ferrandez, Lautrey, Lemoine, & Loarer, 2005a; Rozencwajg, Corroyer, & Altman, 2002; Rozencwajg & Huteau, 1996). The question raised in this new study concerns the impact of assigning a goal that might "force" individuals with low visual–spatial abilities to use strategies they would not employ under normal conditions (because they call for high visual–spatial abilities).

As in other studies, and in direct connection with the observations made in our earlier work, we can assume that subjects with low cognitive abilities will benefit more from a specific, difficult goal. If so, then this would mean that low-ability individuals are capable of applying enough effort to mobilize strategies that they are not normally able to use. In other words, cognitive abilities would not be fixed as one might assume, but can be enhanced by effort. In order to look more specifically at the implications of this hypothesis in our study, we must first describe the task used.

1.2. Samuel, a computerized tool for studying performance and strategies in Kohs Block Design Task

1.2.1. Samuel, a test of general intelligence

The Kohs Block Design Task is usually considered to be a general intelligence test that is highly saturated in factor *g*. Royer, Gilmore, and Gruhn (1984), for example, reported a correlation of .80 between Kohs blocks and IQ assessed on Binet's test. Wechsler used it as a subtest on his child and adult scales. For example, the *g*-loading of Kohs blocks in WISC-IV is .67 (Flanagan & Kaufman, 2004), and its correlation with Weschler's overall score is also high (.59, Wechsler, 2005). For Royer et al. (1984), "It serves, then, as a very good measure of general intelligence, as well as of performance abilities" (p. 1474). Kohs Block Design Task is also classified as a measure of visual processing *Gv*. The *Gv*-loading of Kohs blocks in WISC-IV is .84 (Flanagan & Kaufman, 2004).

1.2.2. Samuel, a test of strategies

The Samuel task, which is derived from Kohs Blocks, was constructed to study the cognitive psychology of problem solving, where the processes and strategies underlying performance on psychometric tests are analyzed (Rozencwajg, 2007; Rozencwajg & Bertoux, 2008; Rozencwajg & Corroyer, 2002; Rozencwajg, Schaeffer, & Lefevbre, 2010). In this task, subjects use red and white colored squares to reproduce two-dimensional, red-and-white square designs composed of geometric figures.

The Samuel task involves copying four model designs consisting of geometric figures displayed on the left-hand side of the screen, using the red, white, and red-and-white squares shown at the bottom of the screen (see Fig. 1). The screen is divided into three main parts. On the left, the test design appears whenever the subject requests and remains on the screen until the subject clicks on a square, at which point the design disappears. Below this, the subject can select a square (an all-red one, an all-white one, or one of four red-and-white ones each oriented in a different way) and drag it up into the black reconstruction area on the right to reproduce the design. The device records the subject's moves for later analysis.

All of the subject's actions (looking at the model, putting a particular square with a specific orientation in a given place, removing it) are recorded automatically. Based on these recordings, two strategy indexes can be calculated: anticipation (number of attempts) and model-viewing frequency. The anticipation index represents the extent to which the subject constructs the design using trial and error, or is able to correctly fill all cells on the first try. For each cell in the design, we obtain a ratio of 1/1 if the cell is correctly filled on the first try, a ratio of 1/2 if the subject takes two tries, a ratio of 1/3 for three tries, etc. The different ratios are added and then divided by the total number of tries. If a cell contains an incorrect square in the end, regardless of the number of tries, the ratio for that cell is 0. For example, for a four-square design where the subject takes one, three, and two tries, respectively, to correctly fill the first three cells, and fills in the last cell with the wrong square in a single try, the calculation would be $(1/1 + 1/3 + 1/2 + 0/1) / (1 + 3 + 2 + 1) = .26$. The anticipation index varies between 0 and 1 (0 if the subject ends up with only incorrectly filled cells, 1 if all cells are correctly filled on the first try). The model-viewing frequency was calculated by dividing the number of times the design was displayed, by the total number of actions.

These indexes are then used to assess the strategy employed by the subject to solve the task. The anticipation index is greater in the analytic and synthetic strategies than in the global strategy, and the model-viewing index is greater in the analytic strategy than in the synthetic strategy. For a sample of 30 subjects 17 years old, anticipation and model-viewing frequency are respectively equal to .76 and .30 for the synthetic strategy, and .80 and .54 for the analytic strategy. For the global strategy, anticipation is equal to .61.

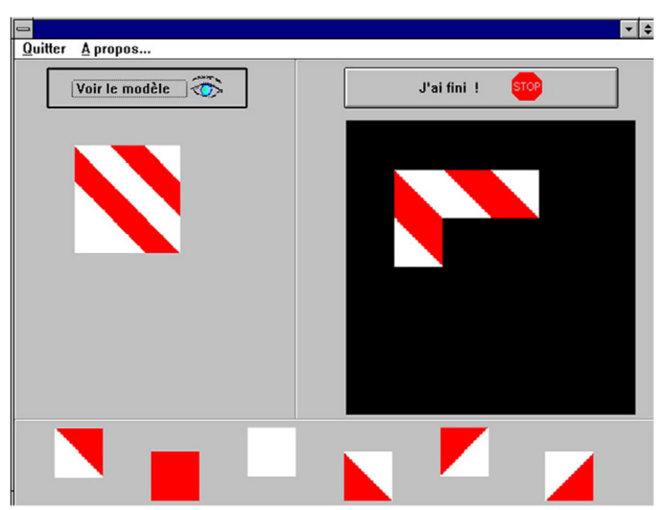

Fig. 1. Samuel screen during design reconstruction.