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Time pressure prevents relational learning

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ABSTRACT

The study investigated the effect of prior experience on two different reasoning tests (Raven's Matrices and Figural Analogy). Each test was divided into two equivalent subtests. Subjects took one subtest either with or without time pressure, after either doing the other subtest as a learning experience under time pressure, or doing it without pressure, or not having the learning experience at all. Time pressure decreased scores for the second subtest. Prior experience of the other subtest under time pressure had no clear effect on scores compared with the no-experience condition. Prior experience without time pressure improved scores (by 25%) for the group taking the second subtest under time pressure but not the scores of the group taking the second subtest without time pressure. We interpret this as meaning that the time pressure prevents relational learning, but such learning can occur within a test when time pressure is relaxed.

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1. Introduction

Numerous forms of learning, especially at early stages of knowledge/skill acquisition (Ackerman, 1986), require the substantial involvement of demanding complex processing, like reasoning, problem solving, and schema induction (e.g., Chuderski, 2013; Doumas, Hummel, & Sandhofer, 2008; Ferretti & Butterfield, 1992; Gentner & Kurtz, 2005; Kaufman, DeYoung, Gray, Brown, & Mackintosh, 2009; Tamez, Myerson, & Hale, 2008; Williams & Pearlberg, 2006). One type of complex learning that is particularly important for the acquisition of structured, conceptually-rich knowledge is *relational learning* (Doumas et al., 2008; Gentner & Kurtz, 2005; Halford, Wilson, & Phillips, 2010; Kemp, Goodman, & Tenenbaum, 2008), that is, learning to understand and use abstract concepts (e.g., "hierarchy"), general rules (e.g., "juxtaposition"), as well as naïve theories of both natural phenomena (e.g. "digestion") and artificial phenomena (e.g., "electricity"). A crucial process underlying such learning is relational reasoning: The systematic and combinatorial processing of structured information (e.g., the mapping of corresponding elements between two structurally matching situations; Holyoak, 2012) that allows people to infer the proper relations between the elements of a given situation. Studies on relational learning cover processes such as abstract concept acquisition (Doumas et al., 2008; Goodwin & Johnson-Laird, 2011; Kemp et al., 2008; Murphy & Medin, 1985), and schema induction by analogy (Hummel & Holyoak, 2003; Markman & Gentner, 2001). For example, by discovering a relational match between two situations, like "providing vitamins improves health", and "detoxifying makes feel better", might lead to the learning of the concept of "homeostasis". (See Fig. 1.)

Because relational learning seems so important for human cognition, the question of factors that may either facilitate or prevent such learning deserves special attention. One important line of research investigated the factors that influence learners' motivation (Pintrich, 2003). Another source for important factors affecting learning is social context (Tiberius & Mancini Billson, 1991). Also, the structure of the problem to be solved (e.g., its coherence with an agent's current goal) seems to be important for how effectively learning proceeds (Gick & Holyoak, 1983). However, relatively less effort was devoted to understanding the role of more situational factors (i.e., the circumstances in which learning occurs) that might impact the effectiveness of relational learning.

The present study aimed to examine the effects on relational learning of one such factor, specifically, the level of time pressure present during a learning episode. As the existing evidence pertaining to the pressure effects on complex learning is very scarce (but see Goldstone & Medin, 1994), the present experiment seems to fill an important gap in the data.

Our general approach was simple: Each of the two standard paper-and-pencil relational reasoning tests that we used, Raven's Advanced Progressive Matrices (henceforth called Raven; Raven, Court, & Raven, 1983), and the Figural Analogy Test (Analogies; see Chuderski & Nęcka, 2012), was split into two subtests. The two subtests were applied in a sequence. It was assumed that when given ample time (150% of the standard administration time) to cope with the subtest applied as first, participants likely induce the types of relations that can exist in that subtest, as well as the strategies that can be used to detect them. They also possibly learn to effectively apply these relations and strategies to find the proper solutions in the subtest applied as second. Thus, in

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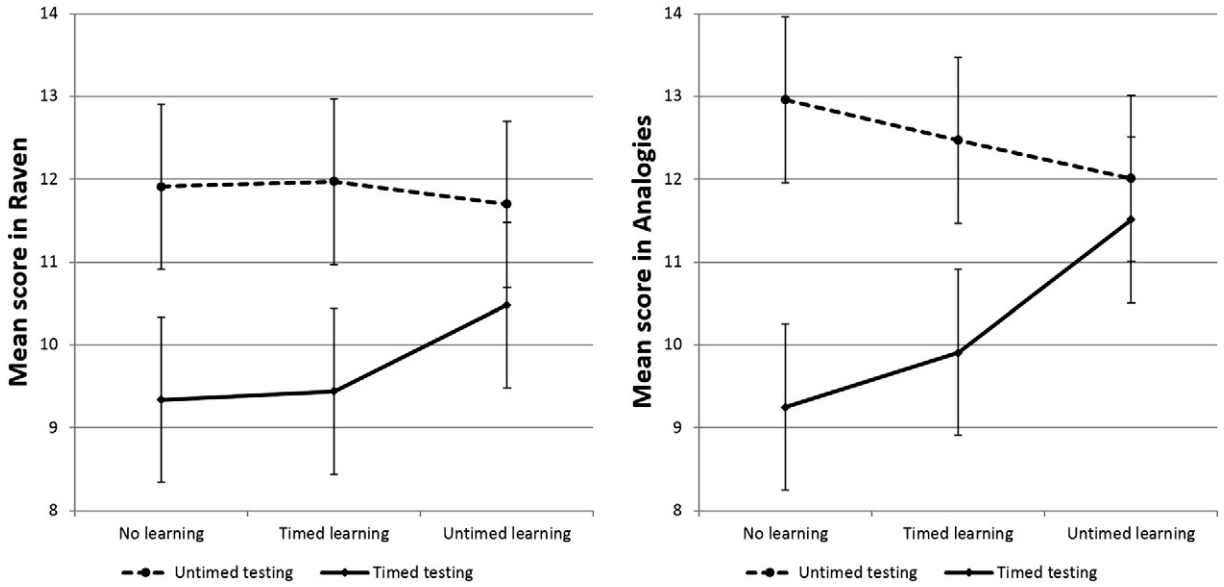

Fig. 1. Mean scores in two reasoning subtests of the Raven Advanced Progressive Matrices (left panel) and the Figural Analogy Test (right panel), which were applied either under time pressure (the timed testing: subtests B and Y; solid lines) or no pressure (the untimed testing: subtests A and X; dashed lines), as a function of whether a preceding subtest was absent (the no-learning group), applied under pressure (the timed-learning group), or applied without pressure (the untimed-learning group). See description in the text. Bars represent 95% confidence intervals.

such an *untimed-learning* condition, the typical test-retest effect should be observed (see Bors & Vigneau, 2003; Colom et al., 2010), evidenced by a significant increase in scores on the second subtest, in comparison to the *no-learning* condition in which people start directly with this subtest, with no previous experience with the first subtest. Crucially, we applied a third possibility (*timed-learning* condition) in which the time on the first subtest was substantially decreased (to 50% of the standard administration time), however still allowing participants to obtain scores comparable to scores on the untimed variant of this subtest. If such a strong time pressure negatively impacts relational learning, then the scores on the second subtest should be significantly lower when the preceding subtest was timed than when it was untimed. Moreover, if time pressure prevents relational learning, then the scores on the subtest preceded by the timed subtest should not differ from the scores in the no-learning condition.

We based our predictions on research on time pressure suggesting that pressure attenuates learning (e.g., Kellogg, Hopko, & Ashcraft, 1999). Importantly, this negative effect is not (at least – solely) related to a simple reduction in time allowed to cope with the task (so, time to learn), because a negative impact on learning seems to primarily result from the subjective feeling of time pressure, even if the time allowed for learning is sufficient to complete a task (DeDonno & Demaree, 2008). Less understood are mechanisms that underlie the negative effect of time pressure on learning. Some research indicated that such pressure might elicit more worried thoughts on the outcome of learning (in comparison to when time pressure is absent), and such thoughts consume cognitive resources of learners, leaving less resources for learning itself (Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998; for contrasting evidence see Kellogg et al., 1999).

It was also shown that time pressure affects the strategies that people use for learning (Mazzoni & Cornoldi, 1993), for example it makes them allocate more processing time to easier fragments of the to-be-learned material, whereas more difficult fragments become neglected. This may diminish the overall outcome of learning (Metcalfe, 2002; Son & Metcalfe, 2000). Especially, such a disruptive effect emerges when all fragments of the to-be-learned material are presented simultaneously (Thiede & Dunlosky, 1999). Moreover, under time pressure participants more often switch to implicit learning (DeKeyser, 2008), for example they use simplified, intuitive, heuristic strategies, which usually are less effective than the full-blown, explicit, analytical strategies. However, sometimes a moderate time pressure was reported to facilitate learning (e.g., Walczyk, Kelly, Meche, & Braud, 1999), especially in situations that require switching between tasks (as it eases the disengaging attention from task to task; Leroy, 2009).

However, most research to date analyzed influence of time pressure on relatively simple learning tasks, like memorizing pairs of words (Metcalfe, 2002), or object drawings (Masur, McIntyre, & Flavell, 1973). As an exception, Goldstone and Medin (1994) examined a more complex process of category induction, and showed that decreasing response deadline during the learning of structural correspondences between perceptual scenes, needed to develop a category, increased performance based on featural (irrelevant) aspects of the scenes, but decreased sensitivity to structural (relevant) similarities. Also, Lerch, Gonzalez, and Lebiere (1999) noted that high time pressure when learning a complex decisional task deteriorated performance on that task, especially in participants possessing less cognitive resources. Both these studies suggest that the negative effect of time pressure may pertain also to complex learning. However, this hypothesis definitely requires more data.

2. Method

2.1. Participants

The effect sizes of retesting in reasoning studies usually amount to about $d \approx 0.5$ (e.g., Colom et al., 2010). Observing such an effect size requires about 70 participants. Thus, similar numbers of people in each experimental group were examined.

Volunteer participants were recruited via publicly accessible social networking websites. Each participant gave informed consent and was paid the equivalent of 15 dollars. A total of 310 people participated (200 women). The mean age was 22.8 years ($SD = 3.36$, range 18–44). Participants were informed that they were free to leave the lab at any time, they knew the general aim of the study ("exploring how people improve their reasoning"), and were aware that their results were anonymous as well as non-diagnostic in every way.

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