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# BENEFITS OF DISTRACTION

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A considerable amount of research has been carried out with the aim of understanding the relationship between arousal and performance, but so far this topic has rarely been examined in the context of personality. In this study, we used a 2-group design ($N = 76$) to investigate the effects of arousal, induced by cognitive activation, on introverts and extroverts in the context of follow-up tasks. Arousal was induced by an irrelevant auditory stimulus that implemented a high cognitive load while participants were attempting to remember the content of the text of an article. Extroverts showed a greater improvement in performance than did introverts in a consecutive task, a d2-Test of Attention, leading to the conclusion that extroverts benefit more from cognitive activation through external stimuli than do introverts. Theoretical implications are discussed in the framework of the Yerkes–Dodson law.

*Keywords:* cognitive activation, extraversion, introversion, arousal, attention, performance, working memory, Yerkes–Dodson law.

The influence of arousal on cognitive performance has been studied for over a century, starting with the Yerkes-Dodson law (Yerkes & Dodson, 1908), according to which there is a nonlinear relationship between arousal and performance, which first improves with increasing arousal but then drops back when arousal levels get too high. The function is described as an inverted U-shaped curve. Although there were some serious limitations in the initial study, the result has been replicated several times in subsequent studies (Mair, Onos, & Hembrook, 2011; Salehi, Cordero, & Sandi, 2010).

Engaging in a cognitive task requires resources and concentration. Everyone has capacity limits and these limits vary (Logie, 2011). If a task becomes increasingly demanding, the individual needs to activate more resources in order

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to execute that task successfully. Further, as task difficulty increases so does arousal level (Reimer & Mehler, 2011), but it has yet to be determined how this process affects performance in consecutive activities and if it affects all individuals in the same way. Our goal in this study was to examine the effects of arousal, induced by cognitive activation, on introverts and extroverts in the context of follow-up tasks.

There are numerous ways to increase arousal. In a number of studies (see e.g., Chang, Labban, Gapin, & Etnier, 2012; Lambourne & Tomporowski, 2010), arousal level has been increased through acute physical exercise in order to measure task performance during and after exercising. Performance results during exercise vary depending on the type and duration of the exercise. The results in studies concerning cognitive performance after exercise are more consistent, showing enhanced performance, especially for tasks that involve rapid decision making and a fast response rate (Chang et al., 2012; Lambourne & Tomporowski, 2010).

Ursin and Eriksen (2004) presented a cognitive theory of stress, in which they explained how arousal levels can be raised by cognitive activation. Most researchers to date have focused on arousal being induced physiologically (see e.g., Eysenck, 2012), whereas our goal was to show how cognitive activation raises arousal levels, leading to an improvement in performance in a cognitive task that follows the cognitive activation process. We suggested that arousal, which is always a physiological process, also originates through cognitive activation. Kofman, Meiran, Greenberg, Balas, and Cohen (2006), for example, measured the executive function of students who were preparing for an examination and for whom tests showed their levels of stress were higher compared to their stress levels at the beginning of the semester. During the stressful period, students performed better on executive function tasks and recorded faster reaction times than during less stressful times.

However, it has not been established whether or not the relationship between arousal and performance always describes the function of an inverted U. Because tests of the Yerkes–Dodson law have not always yielded results in line with the theory set out in the law, it has been criticized as being too simplistic (Bennion, Ford, Murray, & Kensinger, 2013; Hanoch & Vitouch, 2004). We suggested that the conflicting results of studies in which the inverted U-shaped curve has been examined might indicate that the relationship is more complex than is proposed in the Yerkes–Dodson law, and may be influenced by several factors.

Because extroverts have lower arousability levels than do introverts, one of these factors might be extraversion (Brocke, Tasche, & Beauducel, 1997). Whether or not extroverts are underaroused, as originally presumed (Eysenck, 1963), or have lower arousability levels than introverts, extroverts do need more stimulation for their arousal level to increase. Lieberman and Rosenthal (2001) showed that extraversion correlated with central executive efficiency, but not with storage capacity. Extroverts outperformed introverts, especially in tasks that involved multitasking. Campbell, Davalos, McCabe, and Troup (2011) compared the performance of extroverts and introverts on various executive functioning tasks and demonstrated that extroverts outperformed introverts in most of the tasks. Further, as the differences between the two groups became even greater as task difficulty increased. The authors suggested that, as the degree of extraversion became greater, higher levels of dopamine were available, giving extroverts the ability to be more responsive to necessary changes in dopamine activity in relation to some aspects of the task, such as difficulty. Furthermore, in the execution of working memory tasks, extroverts showed a greater benefit than introverts did from an intake of caffeine (Smillie & Gökçen, 2010; Smith, 2013), whereas introverts performed better in the low-arousal condition without caffeine (Smith, 2013).

## The Current Study

Our primary goal in this study was to examine whether or not cognitive activation enhances performance and, if so, whether extroverts benefit more from cognitive activation than introverts do. In accordance with previous research, we expected arousal, induced by cognitive activation, to enhance performance in a follow-up task. We also expected extroverts to experience a greater improvement in performance than introverts did in a task that requires speed and attention, if the task followed cognitive activation.

This difference between introverts and extroverts in the enhancement of performance has been shown to be a physiologically induced activation – e.g., through intake of caffeine – but this did not apply for cognitive activation. We took the view that through cognitive activation induced by auditory distraction, extroverts would outperform introverts in a follow-up task without any physiologically induced activation. For the purpose of this experiment, we assigned the participants to one of three groups according to their level of extraversion. The 25% of the group with the highest score for extraversion on a test of personality traits formed the extrovert group, the 25% with the lowest score for extraversion became the introvert group, and we labeled as ambiverts (people who have introvert and extrovert traits, but in balance) the 50% in between, who had neither very high nor very low scores for extraversion.

We, therefore, proposed the following hypotheses:

***Hypothesis 1:*** When reading a text, auditory distraction will impair the ability of individuals to memorize facts about that text.

***Hypothesis 2:*** When reading a text, auditory distraction will enhance individuals' performance in a follow-up task.

***Hypothesis 3:*** Individuals who are extroverts will benefit more from cognitive activation caused by auditory distraction than will individuals who are either introverts or ambiverts.

## Method

### Participants

In this study, we examined the results of tests completed by 76 students (59 women and 17 men). Recruitment was done by circulating information about the experiment to students at the University of Innsbruck. To fulfill the university's requirements, for a bachelor's degree course students have to participate in experiments for a certain number of hours.

The mean age of participants was 21.1 years (*SD* = 2.4, range = 18-34 years). Of these, 38 were controls with a mean age of 21.2 years (*SD* = 2.1) and 38 were in the experimental group, mean age 21.0 years (*SD* = 2.6).

### Design and Procedure

This experimental study, which was conducted in the facilities of the University of Innsbruck, was a laboratory study in which we used a two-group design. To classify participants according to extraversion and introversion, they completed the short version of the Big Five Inventory (BFI-S; Gerlitz & Schupp, 2005) as part of the application process for the experiment. Up to 10 people at a time were able to participate in the series of sittings we arranged in the laboratory. On a rotating basis, one sitting was assigned to the control condition and the next sitting was assigned to the experimental condition. The participants applied for an appointment time of their choice and did not know which group they would be assigned to.

In the control condition, participants were instructed to read a text and remember as much of it as they could. In the instructions, they were informed that they would have to answer a questionnaire about the text afterwards. Every participant was instructed to read the text just once attentively and was given exactly 10 minutes to do so. There was no time limit set for answering the questionnaire, which consisted of multiple-choice and open questions. After filling out the questionnaire, the participants completed the d2-Test of Attention (Brickenkamp, 1994), which is a measure of attention and concentration. In this task, they worked under time pressure, with a limit of 4 minutes and 40 seconds allowed to complete the task.

In the experimental condition, participants followed the same procedure, with the difference that while reading the text they were hearing a recorded telephone conversation of two people discussing the existence of free will. However, the instructions they were given were clear; they were to remember as much information as possible in the text, and they were explicitly told that the telephone conversation was to be ignored. They were also informed that they would not be questioned later about anything they had heard. Like the control group and under the same conditions in regard to time, the experimental group answered the questionnaire about the text, followed by the d2-Test of Attention.

### Measures

**Big Five.** The short version of the Big Five Inventory (BFI-S; Gerlitz & Schupp, 2005) was developed in order to have a short version in the German language to examine the Big Five personality traits of extraversion, neuroticism, openness, agreeableness, and conscientiousness (Costa & McCrae, 1985). The BFI-S consists of 15 items rated on a 7-point scale (1 = *does not apply*, 7 = *totally applicable*) and was derived from a 25-item scale (Gosling, Rentfrow, & Swann, 2003). In order to validate the BFI-S, it was compared with the longer version. The results of the statistical correlation show that the short version reflects the structure of the longer version. Descriptions of construct validity (Ostendorf & Angleitner, 2004) and convergent validity (Lang, 2005) were made. Cronbach's alpha values were between .53 and .74.

**Visual and auditory stimuli.** The text we selected for use in the experiment was an article called *Science of Happiness and Humanity*, written by Ruckriegel (2007), in which studies about happiness are discussed. It is four pages long and, as already described, the students were given 10 minutes to read it. The questionnaire was developed for the experiment. It contained 14 questions, of which four were multiple choice and 10 were open. All of the information needed to answer the questions was in the content of Ruckriegel's article. We constructed a point system for evaluation purposes, with a maximum possible score of 35 points.

The auditory stimulus for the experimental group was a recorded telephone conversation of two people discussing the existence of free will. Visual and auditory stimuli were both presented in German. The specific topics of both visual and auditory stimuli were intentionally chosen in order to present material that should be of interest to all participants, but did not deal with topics such as religion and politics, which might elicit strong opinions or reactions.

**d2-Test of Attention.** We used the eighth version of the d2-Test of Attention (Brickenkamp, 1994). Participants were required to perform a simple discrimination task by crossing out relevant stimuli and ignoring irrelevant stimuli. Relevant stimuli consisted of the letter d with two dashes above or below the letter. Irrelevant stimuli consisted of the letter d with more or fewer than two dashes above or below the letter and also the letter p, irrespective of the number of dashes and their position. Stimuli were presented to participants on a sheet of paper in 14 rows, with each row containing 47 stimuli. Participants had 20 seconds to respond to the stimuli in a row. After 20 seconds had elapsed, the conductor of the experiment called out "Stop" and they immediately had to switch to the next row. The test result was determined by subtracting errors (misses and false alarms) from the total number of processed stimuli.

Validity and reliability were tested with a group of 4,019 people (Brickenkamp, Schmidt-Atzert, & Liepmann, 2010). Cronbach's alpha values were between .80 and .96, and split-half reliabilities were between .76–.94, showing good internal consistency. Validity was proven by a number of methods, such as construct validity, factorial validity, and empirical validity.

**Working memory capacity.** We measured working memory capacity (WMC) using a set of four tasks (Lewandowsky, Oberauer, Yang, & Ecker, 2010). The set consisted of an updating task, two span tasks, and a spatial task. In a number of experiments, Lewandowsky et al. showed that their WMC battery had high external and internal validity. The composite reliability coefficients they created for two models were between .70 and .79.

**Extraverts, introverts, and ambiverts.** As described above, we used confidence intervals to divide the participants into three groups.

**Expected power.** As already described, we assumed that extroverts would outperform introverts in the follow-up task. If we assumed an effect size of $d$ = 0.5, we could expect the power to be 0.80 (two tailed) for the sample sizes in our study.

## Results

Control group participants scored an average of 18.9 ($SD$ = 4.5) points on the questionnaire and their average d2-Test of Attention score was 508.3. Participants in the experimental group scored an average of 16.4 ($SD$ = 4.6) points on the questionnaire and their average d2-Test of Attention score was 539.0. Means of the two groups were compared with a $t$ test. The control group had significantly higher scores on the questionnaire ($t = 2.41$, $p = .019$) and lower scores in the d2-Test of Attention ($t = -1.72$, $p = .090$). To determine the effect sizes, Cohen's $d$ was calculated (Cohen, 1988), resulting in a medium effect size for the differences in the questionnaire scores ($d = .55$) and a small effect size for the differences in the d2-Test of Attention ($d = .39$). This confirmed our first hypothesis, that auditory distraction would impair performance.

Pearson's correlation coefficients were used to determine whether or not the experimental group scored higher in the d2-Test of Attention than did the control group. There was a correlation between cognitive activation and d2-Test of Attention performance ($r = .196$, $p = .090$), but it was not significant. The second hypothesis could, therefore, not be confirmed, but our result still showed that there was a relationship between d2-Test of Attention performance and cognitive activation.

Extraversion correlated with d2-Test of Attention performance ($r$ = .256, $p$ = .025). Cognitive activation was used as a confounder variable in order to determine whether or not the relationship between extraversion was stronger in the experimental group than in the control group. Controlling for cognitive activation, there was a higher correlation between extraversion and d2-Test of Attention performance ($r$ = .276; $p$ = .017).

In Figure 1, the bar graph shows that introverts, ambiverts, and extroverts all improved their d2-Test of Attention performance in the experimental condition, but to different degrees. The improvement in performance was at a level of significance only for the extrovert group ($t$ = -2.129, $p$ = .045). The difference between the control and the experimental group for the introverts (t = -.575, $p$ = .571) and for the ambiverts ($t$ = -.912; $p$ = .369) was not significant. The difference in effect size between the control and the experimental groups of extroverts was large ($d$ = .87).

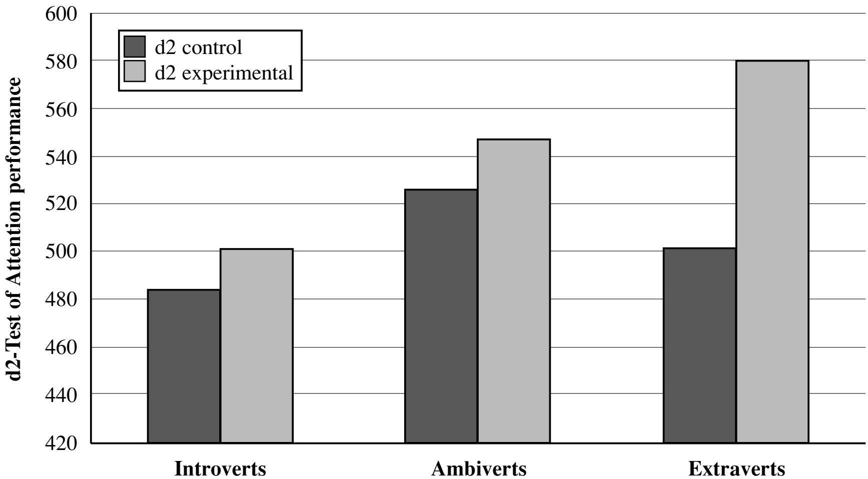


Figure 1. *d2-Test of Attention performance of introverts and extroverts in the control and experimental groups.*

Results of working memory capacity measures showed no significant differences between the control group and the experimental group ($t$ = -0.75; $p$ = .457). We also tested to determine whether or not there was a relationship between extraversion and working memory capacity and the correlation was negative ($r$ = -.236, $p$ = .040).

Cognitive activation did enhance performance in a follow-up task for all participants, but the improvement in performance was greater for extroverts than it was for both introverts and ambiverts. As predicted in our third hypothesis, extroverts benefited more from cognitive activation than did introverts.

## Discussion

As we had anticipated, participants who were not distracted while reading the text remembered more of the content than did those who were distracted. Cognitive activation, caused by the distractive auditory stimulus, considerably improved overall performance in the following d2-Test of Attention, but the improvement was not significant. The result that we found most interesting and that was unexpected for us, was the positive relationship between extraversion and d2-Test of Attention performance that was even stronger in the experimental group than in the control group.

It is our view that this improvement in performance for extroverts was caused by cognitive activation from the previous task. There was also an improvement in performance through cognitive activation for introverts. However, it was small. Whether or not this observation provides evidence in support of, or contrary to, the Yerkes–Dodson law is debatable. Introverts benefited less from cognitive activation in the consecutive task than did extroverts, which could be explained by overarousal and stress. However, in regard to the introvert group in our study, there was no sign of an impairment of performance attributable to too much activation or stress. This finding contradicts the assumptions of arousal theory in its original form (Yerkes & Dodson, 1908).

One possible explanation in neurobiological theory is grounded on the proposal of a dopaminergic basis for extraversion (Depue & Collins, 1999). Findings reported in a previous study have shown differences in working memory performance between individuals high versus low in dopaminergic activity (Malhotra et al., 2002). Cools, Gibbs, Miyakawa, Jagust, and D'Esposito (2008) were able to show that baseline striatal dopamine synthesis was directly predictive of baseline working memory span. Extraversion has been linked to indications of dopamine function (Smillie, Cooper, & Pickering, 2011) and as extroverts seem to have higher levels of dopamine available than do introverts (Campbell et al., 2011), they can enhance their performance, especially when the difficulty or tempo of the task is increased.

Chavanon, Wacker, Leue, and Stemmler (2007) showed that the achievement aspects of extraversion (agentic extraversion; Depue & Collins, 1999), the temporal density of attentional demands of a cognitive task (working memory load; Barrouillet, Bernardin, & Camos, 2004), and dopamine interact to determine both topographical patterns of electroencephalogram (EEG) activity during task performance and the speed of responding to trials imposing high demands on cognitive control.

With regard to this study, our participants' dopamine levels could have been raised through cognitive activation, enabling extroverts to improve their performance more than introverts owing to a high release of dopamine. As the d2-Test of Attention requires a fast response rate, it is likely that extroverts gained higher scores than did introverts because of the triangular relationship between dopamine, extraversion, and performance applying especially to tasks demanding fast responses.

Because extroverts gained higher scores than did introverts in the d2-Test of Attention in both control and experimental groups, it is possible to assume that the reason for this was simply that extraverts have a greater working memory capacity. However, this was not the case. According to our results the relationship between extraversion and working memory capacity was negative, with our results even showing that introverts outperformed extroverts in the working memory capacity battery.

Furthermore, there was no difference in our results for working memory capacity between the control and experimental groups, which is another indicator supporting the assumption that arousal, triggered by cognitive activation, really was the cause – or one of the causes – of the improvement in performance of the extrovert group.

Based on our findings, along with those in previous studies, arousal does seem to enhance performance, but the quality of the performance is influenced by several variables, especially traits that are associated with dopamine, such as extraversion. Thus the Yerkes–Dodson law in its original version (Yerkes & Dodson, 1908) is too simplistic (Hanoch & Vitouch, 2004), because the relationship between arousal and performance is much more complex than was initially assumed. In accordance with findings in previous studies (Campbell et al., 2011; Smillie & Gökçen, 2010; Smith, 2013), we concluded, first, that cognitive activation raises arousal levels just as both caffeine and vigorous exercise do, and, second, that extroverts outperform introverts, especially under high-arousal conditions and in tasks that have high cognitive demands or require a fast response rate. Our results suggest that extroverts can be very productive in a noisy and busy environment, whereas introverts may need a quiet working environment to be able to focus.

One limitation in this study is that extraversion was only measured by questionnaires, which are susceptible to methodological bias. Combining self-reports with physiological measures would help to make results in further studies more convincing. Because neurotransmitters, such as dopamine, appeared to have a role in the relationship between arousal and performance, researchers conducting extensions of this study might consider measuring participants' dopamine levels. The measurement of EEG waves could also contribute to a better understanding of the findings we have presented here.

Furthermore, results showing that enhancement of performance in a cognitive task is caused by processes that happened in a previous task reveal how the tasks can influence each other and, thus, this may lead to methodological bias. The fact that arousal and cognitive activation have different effects on the performance of individuals could be an important topic for investigation by future researchers; not only in terms of how to conduct an experiment methodologically, but also for understanding the role that dopamine plays in the relationship between extraversion and performance.

## Conclusion

We have shown that cognitive activation, without any physiologically induced activation, is sufficient to increase level of arousal and to improve scores on a consecutive task that demands attention and fast response rate. Extroverts in our study experienced a greater improvement in performance through cognitive activation in a follow-up task than did introverts. The results have several implications for industrial and organizational psychology, especially regarding the way individuals deal with the demands of cognitive tasks as well as environmental conditions.

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