Does Media Use Have a Short-Term Impact on Cognitive Performance?
A Study of Television Viewing and Video Gaming
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Abstract. It has often been shown that the amount of media use is negatively related to cognitive outcomes. The more time spent on media the poorer cognitive performance is. This association has mainly been found for general-audience, violent, and action-loaded contents but not for educational contents. Typically, long-term-explanations like the time-displacement hypothesis are considered to account for this relation, although this cannot fully explain the association. Additionally short-term explanations should be considered, since it can be expected that media-induced stress can impair information processing. The present study compares short-term effects regarding memory performance and the ability to concentrate, using four different experimental conditions (high- vs. low-arousing films and video games). It was also examined if the experienced level of stress mediates group differences and if habitual media, habitual use of age-restricted contents or the trait sensation seeking moderate this mediation. Participants consisted of $N=117$ university students. They were asked to learn written items before media use and to recall these after having used the media. Further, the ability to concentrate was measured. Experimental groups differed with regard to the cognitive outcome measures after media use. A significant univariate difference was found for high- vs. low-arousing contents in general (independent of type of media), the high-arousing content leading to poorer ability to concentrate after media use. The expected mediating and moderating effects are not supported. The study yields evidence that short-term mechanisms might play a role in explaining the negative correlations between media use and cognitive performance.

Keywords: ability to concentrate, cognitive performance, memory, television, video games

Introduction

Since the use of electronic entertainment media devices such as television, video games, and computers has become one of the main recreational activities for children, adolescents, and young adults (Bennijes, Koolstra, Marseille, & van der Voort, 2001; Rideout, Roberts, & Foehr, 2005), there is a vast interest in the effects of this media use on developmental and behavioral factors (Huesmann & Taylor, 2006). One branch of research focuses on the impact media use has on learning abilities, cognitive performance, and academic achievement (for overviews, see Kirkorian, Wartella, & Anderson, 2008; Schmidt & Vandewater, 2008).

There is no generally accepted agreement on the expectations regarding the effects of media use on cognitive performance. Some studies found a positive impact especially of computer gaming on cognitive outcomes. It is reported, for example, that habitual players of action video games show shorter reaction times (Bialystok, 2006; Castel, Pratt, & Drummond, 2005; Dye, Green, & Bavelier, 2009) and a faster information processing of visual information (Li, Polat, Makous, & Bavelier, 2009). Further, it was shown that habitual action game players possess an enhanced attentional capacity and an enhanced allocation of spatial attention as compared with nonplayers (Green & Bavelier, 2003). The last-mentioned study also shows that nonplayers can be trained by playing an action video game for 1 hr across several consecutive days and that this training leads to an increase in the capacity of visual attention. It should however be considered that the dependent measures of these studies are very similar to competences which are necessary to successfully master an action video game and are therefore directly trained by it. Therefore, measures of cognitive outcomes which cover other aspects of cognitive performance should also be looked at.

Several longitudinal studies reveal that the amount of media use is detrimentally related to attentional problems (Christakis, Zimmermann, DiGuisepppe, & McCarty, 2004; Johnson, Cohen, Kasen, & Brook, 2007; Özmert, Toyran, & Yurdakök, 2002), reading performance (Ememose & Schneider, 2007; Koolstra, van der Voort, & van der Kamp, 1997), and general academic outcomes (Hancox, Milne, & Poulton, 2005; Johnson et al., 2007; Özmert et al., 2002; Zimmermann & Christakis, 2005) even if IQ, socioeconomic status, and other relevant variables are being controlled. It should however be considered that the quantity of media use is apparently less important than the quality of media content. The negative correlations are mainly found for entertainment and general-audience contents (Wright et al., 2001), especially for violent video games or...
movies (Hastings et al., 2009; Sharif & Sargent, 2006). These formats are preferred by the majority of children, adolescents, and young adults; boys in particular prefer action-loaded and violent contents (Funk, 2005; Garitaonandia, Juaristi, & Oleaga, 2001; Möble, Kleimann, Rehbein, & Pfeiffer, 2006). In contrast, educational, informational, or learning contents can have a positive impact on cognitive outcomes (Hastings et al., 2009; Schmidt & Anderson, 2006; Wright et al., 2001).

Since the current state of research suggests that certain media contents can be associated with detrimental impacts on cognitive outcomes, the question regarding possible explanations for this relation arises. Usually different long-term explanations are considered in this context. Firstly, the time-displacement hypothesis suggests that the time spent with media displaces time for more beneficial activities such as reading, learning, or doing homework. While some studies support this assumption (i.e., Shin, 2004; Wiecha, Sobol, Peterson, & Gortmaker, 2001), others do not lead to such conclusions (i.e., Hastings et al., 2009). Additionally, the mental-effort-passivity hypothesis assumes that consuming media does not require a high mental effort and that this leads to mental laziness. It is therefore expected that individuals who are exposed to a lot of media entertainment do not spend a lot of effort on academically more beneficial activities (Salomon, 1984). Other long-term explanations, such as the attention-arousal hypothesis, assume that the fast-changing media contents with their rapid movements and scene cuts inhibit engagement in sustained and task-oriented activities and may lead to impulsive and inattentive behavior. These hypotheses have been partially supported, for instance, by Shin (2004) but cannot completely explain the negative association between cognitive outcomes and the consumption of certain media contents.

Therefore, other explanations may exist which account for the impairment of cognitive performance due to media use. There is evidence that besides long-term explanations, short-term effects also might play a role. A recent study by Dworak, Schierl, Bruns, and Strüder (2007) reveals that singular exposure to exciting media contents has a negative impact on verbal but not on visuospatial memory performance. This was shown for computer games but not for television. The participants in this study were first asked to memorize given items, second they watched a movie or played a game, then slept for a night, and finally recalled the learned material from the previous day. The authors attributed the decline in memory performance to media-induced changes of sleep patterns, which can have an impact on learning and memory processes.

Further evidence for short-term explanations can be found in research on advertising effects. Several studies show that memory for commercials is worse when they are embedded with emotionally disturbing and violent contents (Maass, Wolf, & Lohaus, 2010). Besides physiological stress, the subjectively experienced stress is also higher for arousing and violent contents than for nonviolent contents (Maass et al., 2010). Corresponding to this, Bushman (1998) reports that learning and memorizing commercials is especially poor if participants experience higher levels of negative feelings and anger during media exposure.

Whether the media-induced stress reactions can significantly impair cognitive performance has not been systematically investigated yet. Considering the recent results of research, it is to be expected that high-arousing contents lead to poorer cognitive performance than low-arousing contents. To include different cognitive measures besides memory performance, the ability to concentrate was also considered in this study.
Further, it is examined whether there are differences with regard to the different types of media, with especial focus on television and video games. The recent literature on differences between television and video games differs as to which of the two has stronger effects on the user. On the one hand, it is expected that, due to their interactive and more involving character, video games might have a stronger effect on the experience of stress and therefore, in turn, on cognitive performance in comparison with television (Gentile & Anderson, 2003). Corresponding to this, Calvert and Tan (1994) found that physiological arousal is higher for individuals who observe a video game in contrast to active players of the same game. Moreover, cardiovascular activity was higher for users of a video game compared with those who watched a comparable television program (Maass et al., 2010). On the other hand, Sherry (2004) reports in his meta-analysis that video game violence has a smaller effect on aggression than television violence, which supports the contrary assumption that television might have a greater influence on behavioral and physiological factors. Therefore, the present study examines if there are differences between video games and television with regard to their effects on cognitive performance.

Moreover, sex differences are explored because sex-specific patterns of habitual media use might lead to differential effects. It is well known that males prefer action-loaded and violent media formats and that they therefore are more used to and desensitized to these kinds of contents (Cherney & London, 2006; Funk, 2005; Garitaonandia et al., 2001). Hence, they might show lower stress reactions, especially toward arousing media contents, and thus the effects on cognitive performance would be expected to be smaller in males than in females.

It is further investigated if the relations between media content, as well as media types and cognitive performances, are mediated through differential levels of media-induced stress. It is expected that differences in cognitive performance can be explained through higher levels of subjective experienced stress for high-arousing in contrast to low-arousing contents. This is further analyzed by comparing television and computer games. The stress reaction might therefore be the key in explaining short-term media effects on cognitive processes.

Finally, possible moderator variables are considered in order to investigate if there are additional group-specific effects. It is expected that the habitual use of media and especially the frequent use of violent and age-restricted media contents lead to habituation and desensitization with regard to arousing media contents. It is further expected that individuals with high amounts of habitual use of media in general or use of age-restricted media formats show lower stress experiences than those with less amounts of habitual use. Therefore, it is analyzed if the mediating effect of experienced stress on the relation between media content as well as media types and cognitive performances is moderated by the habitual use of media or especially the habitual use of violent media contents (see Figure 1). Another possible moderator might be the trait sensation seeking, which describes the disposition to seek novel experiences and various sensations and the willingness to take the risk of physical or social harm to achieve these experiences (Zuckerman, 1994). Sensation seeking is a well-examined construct in the research on media use and media effects. Several studies reveal that high sensation seekers prefer emotionally arousing and violent media contents which are accompanied by negative emotions and feelings of tension (Banerjee, Greene, Krcmar, & Bagdasarova, 2009; Banerjee, Greene, Krcmar, Bagdasarova, & Ruginyte, 2008; Greene, Krcmar, Walters, Rubin, & Hale, 2000; Hoffner & Levine, 2007; Slater, 2003; Zuckerman, 1988). Therefore, high sensation seekers are presumably more used to these kinds of media content and therefore show lower stress reactions. Sensation seeking might also serve as a moderator, in that higher levels of sensation seeking lead to less subjective experienced stress. Hence it is expected that the mediation effects of experienced stress on the relation between media content as well as media types and cognitive performances are moderated by sensation seeking (see Figure 1).

To sum up, the present study focuses on the following hypotheses:

Hypothesis 1 (H1): It is expected that high-arousing contents lead to poorer cognitive performance than low-arousing contents (in terms of memory performance and ability to concentrate). It is analyzed additionally if there are any differences between video games and television with regard to the effects on cognitive performance.

Hypothesis 2 (H2): The effects on cognitive performance are expected to be smaller in males than in females.

Hypothesis 3 (H3): It is expected that differences in the cognitive performances between high- and low-arousing contents and between television and computer games are mediated through subjective experienced stress.

Hypothesis 4 (H4): It is expected that the mediation effects of experienced stress on the relation between media content as well as media types and cognitive performances are moderated by (a) the habitual use of media, (b) the habitual use of age-restricted violent media contents, or (c) sensation seeking (see Figure 1).
Methods

Sample

Participants consisted of university students \((N = 117; 64\) female) from a German university. All participants – at least occasionally – played computer games in their spare time and therefore were experienced and able to control and handle the games. Further, none of the participants was familiar with the Turkish language, which was a requirement for participation due to the memory testing described below.

Participation was voluntary and anonymous. As an incentive, the participants had the option to choose between a certificate of participation (German psychology students are required to participate in scientific studies for a defined number of hours) or participation in a draw for several gift vouchers. The students’ ages ranged from 18 to 30 years, \(M = 22.10\) years \((SD = 2.52)\).

Experimental Conditions

Four experimental conditions were differentiated. To create comparable groups, the video games and television programs were parallelized by choosing comparable content. For the high-arousing conditions the video game *Doom* (by Id Software, 2004) and a game-like excerpt of the film with the same title (directed by Andrzej Bartkowiak, 2005) were chosen. Both contain horror and fighting scenes from an ego-shooter perspective. The protagonist has to defend himself and fight against various monsters and manlike opponents. Both game and film are accompanied by dark scenery and arousing background music. For the low-arousing television condition, a recorded tennis match was presented. The video game *Professional Tennis* (by Astragon Software, 2006) was used as the low-arousing game. In this game, the player has to complete a tennis match by controlling one of the tennis players. All games and television programs were presented on laptop computers with headphones.

To validate whether the *Doom* conditions were experienced as more arousing than the tennis conditions, the participants were asked to rate their subjective experienced stress during media use (see below) and to judge the level of violence of the presented content on a scale from 0 to 10.

Procedure

Participants were tested in small groups of one to four students. Each group was randomly assigned to one of the experimental conditions. The assignment of the participants to the groups is presented in Table 1. There are no age or sex differences between the experimental conditions. The experiment was conducted in a laboratory at Bielefeld University and took approximately 90 min for each of the experimental groups. For an overview of the experimental procedure see Table 2.

Measures

Sociodemographic Information

Participants were asked to specify their sex, their field of study, and their age.

Memory Testing

Two subtests of a German learning and memory test (LGT-3; Bäumler, 1974) were used to measure the memory

<table>
<thead>
<tr>
<th>Table 1. Assignment of the participants to the experimental conditions, and average group sizes</th>
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</thead>
<tbody>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Total</td>
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<td>Average group size</td>
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<table>
<thead>
<tr>
<th>Table 2. Course of the experimental procedure</th>
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<tbody>
<tr>
<td>Duration (including instructions)</td>
</tr>
<tr>
<td>1. Reception of participants, completion of informed consent</td>
</tr>
<tr>
<td>2. Assessment of general intelligence</td>
</tr>
<tr>
<td>3. Questionnaires on sociodemographic information and sensation seeking</td>
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<tr>
<td>4. Assessment of ability to concentrate (baseline)</td>
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<tr>
<td>5. Memory testing: Learning phase</td>
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<tr>
<td>6. Media use</td>
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<tr>
<td>7. Assessment of ability to concentrate</td>
</tr>
<tr>
<td>8. Memory testing: Recall phase</td>
</tr>
<tr>
<td>9. Questionnaire on subjective experienced stress during media use and habitual media use</td>
</tr>
<tr>
<td>Total: 90 min</td>
</tr>
</tbody>
</table>
performance. These subtests were chosen because they represent typical learning materials used in schools. The first subtest contained 20 German-Turkish words which the participants had to learn in 90 s. The words were all presented simultaneously on a single page. The second subtest consisted of a short informational text. This text focused on several details of a planned construction for a new library (e.g., name of the library, costs, and names of the architects). The subjects were instructed to thoroughly read and memorize the information presented in the text. The time limit was again set at 90 s. The subtests were presented consecutively.

After the media use (30 min later), the students were asked to recall the memorized items. The vocabulary items were presented in a multiple-choice response format. Twenty German words were each presented with five different Turkish words, whereby the participants had to choose the correct translation. The informational items were recalled using 24 open questions. The subjects had to write down the correct word or number for which they had been asked.

Correlation between the performance on both subtests was \( r = .48 \) (\( p < .01 \)). To combine both test results to obtain a single test score for memory performance, individual scores for each subtest were converted in standardized \( z \)-scores and then summed up.

### Ability to Concentrate

Ability to concentrate was measured using a well-established German test of short-term selective concentration (Test d2; Brickenkamp, 2002). Subjects are instructed to mark specific symbols (\( d \)s with two dashes) in 14 rows with several distractor symbols (\( d \)s with more or less than two dashes as well as \( p \)s and \( b \)s with dashes). Each row contains 47 symbols. A time limit of 20 s for each row was set according to the test manual, totaling at 4 min 40 s. The number of correctly marked symbols, minus the number of wrongly marked symbols was determined as the test score, as suggested in the test manual. The reported internal consistencies were above \( \alpha = .95 \) and test-retest reliability amounted to \( r = .84 \) for a time interval of 3 months (Brickenkamp, 2002). The ability to concentrate (baseline measure before media use) did not differ significantly between the experimental groups, \( F(3, 113) = 1.09, \) n.s.

### Sensation Seeking

Sensation seeking was assessed using 10 items derived from the subscale “Thrill and Adventure Seeking,” from the German version of the Sensation Seeking Scales (Beauducel, Strobel, & Brocke, 2003) originally developed by Zuckerman, Eysenck, and Eysenck (1978). The items of this subscale describe the tendency to favor dangerous and exciting activities. This subscale was chosen because it can easily be related to media use – for example, preference of contents which are exciting and thrilling. The items contain two different statements each; one stands for high sensation seeking (coded as 1; e.g., “I sometimes like to do things that are a little frightening”), and the second for low or no sensation seeking (coded as 0; e.g., “A prudent person avoids dangerous activities”). The participants have to decide which statement they prefer and with which they tend to agree. A sum score of all items was determined to obtain a single score. Internal consistency of the presented items was \( \alpha = .68 \). The four experimental groups did not differ significantly with regard to their reported level of sensation seeking, \( F(3, 113) = .24, \) n.s.

### General Intelligence

General intelligence was measured using 19 selected items of the Advanced Progressive Matrices (APM; Raven, Raven, & Court, 1998). The APM is a nonverbal pencil and paper intelligence test for adolescents and adults. Participants had to complete figural patterns by choosing one out of eight different options for each case. A time limit of 10 min was set for the completion of the test. The internal consistency of the 19 presented items was \( \alpha = .69 \). Participants correctly solved \( M = 10.64 \) (SD = 2.54) of the items on average. The four experimental groups did not differ significantly with regard to their level of general intelligence, \( F(3, 113) = .70, \) n.s.

### Subjective Experienced Stress During Media Use

A questionnaire developed for the present study was used to measure subjective experienced stress during media use. Sixteen items (e.g., “I was nervous” and “I felt overstrained”) with an internal consistency of \( \alpha = .93 \) were presented after the media use. Subjects were asked to answer on a 4-point Likert scale consisting of stages: 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. The mean of all test items was calculated to obtain a single score of subjective experienced stress.

### Habitual Media Use

Subjects rated their media use by answering the questions: “How many hours do you spend in front of the TV on an ordinary day?” and “How many hours do you play video or computer games on an ordinary day?” To obtain a single score of hours spent on the daily media use, the sum score of both items was determined. Further, the participants were asked how often they (a) watch age-restricted films or television programs and (b) play age-restricted video or computer games which are not permitted for children or adolescents due to the level of violence. The options ranged from 1 = never, 2 = rarely, 3 = sometimes, and 4 = often. The mean of the two items was determined to obtain a single score for the use of age-restricted media contents. The experimental groups did not differ significantly in any of these items: hours of TV: \( F(3, 112) = 1.67, \) n.s.; hours of games: \( F(3, 112) = 1.34, \) n.s.; age-restricted films: \( F(3, 112) = 1.04, \) n.s.; age-restricted games: \( F(3, 112) = .86, \) n.s.
Statistical Analysis

Group comparisons were calculated using univariate or multivariate analyses of variance, followed by post hoc multiple comparisons with adjustment of α (Bonferroni procedure). To control for effects of other relevant variables, covariates were included. In the case of memory performance and ability to concentrate after media use as dependent variables, general intelligence and the baseline measure of ability to concentrate were included as covariates since they are expected to affect cognitive performances after media use. Further, for practical reasons, the four experimental groups differed in group size (see Table 1), which is why group size was also included as a covariate to obviate the possibility that group size had an impact on cognitive performance.

Mediation effects were tested by the causal steps approach proposed by Baron and Kenny (1986), also described by Frazier, Tix, and Barron (2004). To test the mediation hypothesis, four conditions must be met: First, there has to be a significant effect of the predictor on the criterion. Second, there has to be a significant effect of the predictor on the mediator. Third, there must be a significant effect of the mediator on the criterion controlling for the predictor, and fourth, the residual effect of the predictor (when the mediator is considered) should be smaller than the direct effect of the predictor on the criterion. This is conducted in three consecutively linear regressions, in which (1) the criterion is regressed on the predictor, (2) mediator is regressed on the predictor, and (3) the criterion is regressed on both the predictor and the mediator. If the effect of the predictor is reduced when the mediator is added in the last step, this should be tested for significance using the Sobel test or comparable measures (see Baron & Kenny, 1986; Sobel, 1982).

The assumed moderated mediation was analyzed by a method described by Muller, Judd, and Yzerbyt (2005). This method is based on three consecutive linear regressions. In a first step, both mediator and moderator are z-standardized. The first regression assesses whether there is an overall effect of the predictor on the criterion and whether this effect is moderated (\(Y = \beta_{c0} + \beta_{c1}X + \beta_{c2}Mo + \beta_{c3}X \times Mo + \beta_{c4}Me + \beta_{c5}X \times Me + E\)). To assess this, the product term of moderator and predictor is included (which corresponds to \(H_4\), \(a\), and \(c\)), or \(\beta_{c1}\) and \(\beta_{c4}\) should be significant to confirm that the effect of the predictor on the mediator is moderated (which corresponds to \(H_4\), \(b\), and \(c\), or \(\beta_{c2}\), \(\beta_{c3}\), and \(\beta_{c5}\) should be significant to show that the mediator’s (partial) effect on the criterion or on the residual effect of the predictor on the criterion, controlling for the mediator, are moderated (which is not assumed in the present study but is part of the analysis of moderated mediation). To consider the baseline assessments of the measures of cognitive performance, standardized residuals were determined in a first step and then used in the analyses. The residuals contain the parts of the outcome measures which cannot already be explained or predicted by the baseline measure.

Results

Validation of the Experimental Conditions

The assumption that Doom is experienced as more stressful was supported, \(F(3, 113) = 13.07, p < .01, \eta^2 = .26\) (for means and standard deviations, see Table 3). Post hoc tests reveal that both the game and television program led to higher experienced stress, when compared with both game and television program of the tennis condition \((p < .01\) each). There were no differences in the high-arousing condition between video game and television; nor within the low-arousing condition, when comparing the different types of media. Further, level of violence was rated higher for Doom than for both the tennis game and television program, \(F(3, 113) = 382.91, p < .01, \eta^2 = .91\) (for means and standard deviations, see Table 3). Again, no differences could be found between the different types of media within the Doom or tennis condition. The correlation between experienced stress during media use and rating regarding level of violence was \(r = .54\) \((p < .01)\).

Differences in Cognitive Performances Between the Experimental Groups and Between Sexes (Hypotheses 1 and 2)

To test \(H_1\) and \(H_2\), a MANCOVA with two independent variables (experimental condition and sex) and two dependent variables (memory performance and ability to

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Table 3. Means and standard deviations (in parentheses) of different measures separated by experimental groups

<table>
<thead>
<tr>
<th></th>
<th>Low-arousing film</th>
<th>Low-arousing game</th>
<th>High-arousing film</th>
<th>High-arousing game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced stress</td>
<td>1.62 (.49)</td>
<td>1.78 (.41)</td>
<td>2.39 (.76)</td>
<td>2.32 (.58)</td>
</tr>
<tr>
<td>Experienced level of violence</td>
<td>.75 (1.32)</td>
<td>.48 (1.35)</td>
<td>8.66 (.90)</td>
<td>8.03 (1.30)</td>
</tr>
<tr>
<td>Ability to concentrate (after media use)</td>
<td>246.44 (37.10)</td>
<td>231.14 (40.00)</td>
<td>229.00 (41.20)</td>
<td>220.19 (30.22)</td>
</tr>
<tr>
<td>Memory performance</td>
<td>.23 (1.79)</td>
<td>.12 (1.89)</td>
<td>.08 (1.69)</td>
<td>-.55 (1.72)</td>
</tr>
</tbody>
</table>
concentrate after media use), was conducted with three covariates – general intelligence, ability to concentrate (baseline), and group size – and revealed a main effect for experimental condition, \( F(6, 210) = 2.53, p < .05, \eta^2 = .067 \) (see Table 3), and for sex, \( F(2, 104) = 3.88, p < .05, \eta^2 = .069 \), but no interaction effect, \( F(6, 210) = .63, n.s. \) Post hoc tests showed that the experimental conditions differed in the ability to concentrate, \( F(3, 105) = 3.52, p < .05, \eta^2 = .091 \), but not with regard to memory performance, \( F(3, 105) = 1.59, n.s., \) although the hypothesized differences were supported by trend (see Table 3). Further group comparisons illustrate that high-arousing contents in general, independent of the type of media, led to a poorer ability to concentrate after media use than low-arousing contents: high-arousing: \( M = 224.45, SD = 35.91 \), low-arousing: \( M = 238.52, SD = 39.04 \); \( F(1, 111) = 6.43, p < .05, \eta^2 = .055 \).

Independent of the experimental conditions, the two sexes differed significantly in memory performance: female: \( M = .39, SD = 1.61 \); male: \( M = -.52, SD = 1.86 \); \( F(3, 105) = 6.41, p < .05, \eta^2 = .058 \). Female participants showed better results (see Table 4), but not in their ability to concentrate: female: \( M = 232.03, SD = 37.31 \); male: \( M = 230.30, SD = 39.04 \); \( F(1, 105) = 1.29, n.s. \) Except for one, none of the covariates significantly affects the outcome measures: Only the baseline measure of the ability to concentrate has a significant effect on the ability to concentrate after media use, \( F(2, 104) = 122.23, p < .01, \eta^2 = .702 \).

### Subjective Experienced Stress as Mediator (Hypothesis 3)

Since high- and low-arousing media contents differed in the present study significantly with regard to cognitive performance – more precisely in the ability to concentrate, a dichotomous variable (0 = low-arousing media content, 1 = high-arousing media content) was introduced as a predictor variable in the regression. Subjective experienced stress during media use was considered as mediator variable.

Although the relation between high- versus low-arousing contents and ability to concentrate was reduced and no longer significant when subjective experienced stress was included in the third regression in step three, the mediation analysis revealed that subjective experienced stress during media use was not related to the ability to concentrate after media use (see Table 4) and did not therefore serve as a mediator variable, since the conditions for a mediation were not met. Consequently, experienced stress does not (partially) explain the relationship between level of arousal and ability to concentrate. Therefore, H3 cannot be supported.

### Analysis of Moderated Mediation Effects (Hypothesis 4a, b, c)

Beside the predictor variable (0 = low-arousing media content, 1 = high-arousing media content), three different variables (hours of media use per day, frequency of use of age-restricted media contents, and sensation seeking) were included as possible moderator variables in the analysis on moderated mediation. As mediator, the subjective experienced stress during media use was again considered (compare Figure 1). The results are reported in Tables 5, 6, and 7, and show that in none of the analyses either \( \beta_{b3} \) and \( \beta_{b4} \) or \( \beta_{c4} \) and \( \beta_{c5} \) reached statistical significance. Therefore H4a, b, and c was not supported by the data. The mediation between media content and cognitive performances through experienced stress was not moderated either by the habitual use of media, or by the habitual use of age-restricted violent media contents, or by sensation seeking.

### Discussion

The results of this study support the assumption that high-arousing media contents lead to a less effective processing of information and an impaired cognitive performance, directly after the use of media. These findings therefore correspond to findings from other research groups (e.g., Bushman, 1998; Dworak et al., 2007; Mundorf et al., 1991; Prasad & Smith, 1994). A closer look at the descriptive results for the different experimental groups reveals that cognitive performance was at its poorest for the high-arousing game, followed by the high-arousing film, the low-arousing game, and the low-arousing film for memory performance and ability to concentrate (Table 3). The

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**Table 4. Results of the multiple linear regressions of the mediation analysis**

<table>
<thead>
<tr>
<th>Regression</th>
<th>Criterion</th>
<th>( B )</th>
<th>SE</th>
<th>( \beta )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (after media use)</td>
<td>ability to concentrate</td>
<td>High- versus low-arousing content</td>
<td>-.43</td>
<td>.19</td>
<td>-.21*</td>
</tr>
<tr>
<td>2 (after media use)</td>
<td>subjective experienced stress</td>
<td>High- versus low-arousing content</td>
<td>.65</td>
<td>.10</td>
<td>.50**</td>
</tr>
<tr>
<td>3 (after media use)</td>
<td>ability to concentrate</td>
<td>High- versus low-arousing content</td>
<td>-.42</td>
<td>.22</td>
<td>-.20*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subjective experienced stress during media use</td>
<td>-.62</td>
<td>.17</td>
<td>-.01</td>
</tr>
</tbody>
</table>

Note. * \( p < .05 \), ** \( p < .01 \).
hypotheses regarding group differences were supported by a multivariate analysis of variance. Significant univariate differences could be found for high-versus low-arousing contents with regard to the ability to concentrate.

The assumption that the effect of high-arousing contents on cognitive performance is mediated through the experienced level of stress was not supported, although experienced stress was – as could be expected – higher for high-arousing than for low-arousing contents. Therefore, this study does not show that the explanation for the relationship between media content and cognitive outcomes is the stress experience.

### Table 5. Results of the analyses on moderated mediation (moderator: frequency of media use)

<table>
<thead>
<tr>
<th>Criterion: Ability to Concentrate</th>
<th>Criterion: Experienced Stress</th>
<th>Criterion: Ability to Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>SE</td>
<td>β</td>
</tr>
<tr>
<td>High-versus low-arousing content</td>
<td>−.73</td>
<td>.35</td>
</tr>
<tr>
<td>Frequency of media use (Moderator)</td>
<td>.96</td>
<td>.68</td>
</tr>
<tr>
<td>High-versus low-arousing content</td>
<td>.50</td>
<td>.40</td>
</tr>
<tr>
<td>Frequency of media use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress (Mediator)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of media use *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress</td>
<td>−.03</td>
<td>.18</td>
</tr>
</tbody>
</table>

**Note.** *p < .05, **p < .01.

### Table 6. Results of the analyses on moderated mediation (moderator: frequency of use of age-restricted media contents)

<table>
<thead>
<tr>
<th>Criterion: Ability to Concentrate</th>
<th>Criterion: Experienced Stress</th>
<th>Criterion: Ability to Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>SE</td>
<td>β</td>
</tr>
<tr>
<td>High-versus low-arousing content</td>
<td>−.78</td>
<td>.54</td>
</tr>
<tr>
<td>Frequency of use of age-restricted media contents (Moderator)</td>
<td>.57</td>
<td>.59</td>
</tr>
<tr>
<td>High-versus low-arousing content</td>
<td>−.19</td>
<td>.38</td>
</tr>
<tr>
<td>Frequency of use of age-restricted media contents *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress (Mediator)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of use of age-restricted media contents *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress</td>
<td>.03</td>
<td>.19</td>
</tr>
<tr>
<td>Frequency of use of age-restricted media contents *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress</td>
<td>−.22</td>
<td>.24</td>
</tr>
</tbody>
</table>

**Note.** *p < .05, **p < .01.

### Table 7. Results of the analyses on moderated mediation (moderator: sensation seeking)

<table>
<thead>
<tr>
<th>Criterion: Ability to Concentrate</th>
<th>Criterion: Experienced Stress</th>
<th>Criterion: Ability to Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>SE</td>
<td>β</td>
</tr>
<tr>
<td>High-versus low-arousing content</td>
<td>−.88</td>
<td>.32</td>
</tr>
<tr>
<td>Sensation seeking (Moderator)</td>
<td>−1.31</td>
<td>.57</td>
</tr>
<tr>
<td>High-versus low-arousing content</td>
<td>.67</td>
<td>.34</td>
</tr>
<tr>
<td>Sensation seeking *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress (Mediator)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensation seeking *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced stress</td>
<td>−.05</td>
<td>.18</td>
</tr>
</tbody>
</table>

**Note.** *p < .05, **p < .01.
Further, the considered possible moderator variables did not moderate the relationship between content and subjective experienced stress; therefore, the hypotheses regarding moderated mediation were not supported. It does not seem to matter whether someone is a high or a low sensation seeker, or whether someone is used to a lot of media exposure, particularly with violent media contents. The effects of the media content on the subjective experienced stress remain the same, independent of the possible moderators mentioned.

The results regarding differential effects of high- versus low-arousing media contents on cognitive performance support the assumption that beside long-term effects, short-term mechanisms also may be important for explaining the negative correlation between media use and cognitive outcome measures. Further research is certainly needed to confirm this thesis. Nevertheless, the present study reveals some initial evidence that it is worthwhile and indispensable to consider these short-term effects in further studies which focus on media effects.

The question regarding the explanations for the effect remains unanswered, since the experienced stress does not serve as a mediator in this context. This might be due to the fact that the present study only considered the subjectively experienced stress instead of more objective measures of physiological stress reactions. Subjectively experienced stress is not necessarily correlated with physiological stress reactions and vice versa (Hébert et al., 2004; Myrtek, Scharrf, Brügner, & Müller, 1996). Physiological reactions are not always accompanied by corresponding subjective experiences, and feelings of stress or arousal are not always identifiable in analogous bodily reactions. But, as neuropsychological studies show, physiological reactions may be more important in explaining the effects on cognitive processes than the subjectively experienced stress (De Quervain et al., 2000; Kirschbaum et al., 1996; Kuhlmann et al., 2005). Therefore, the reason for the missing support for the hypothesis of mediation may be the fact that the subjectively experienced stress may not reflect the bodily processes. Since it is mainly the bodily stress which might impair the cognitive impairment, further studies should also concentrate on physiological stress reactions, which can be identified by measuring the heart rate or by analyzing changes in the concentration of stress-related hormones and neurotransmitters. These rather objective measures might be more relevant for the short-term media effects on cognitive performance than subjective ratings of individual feelings and experiences.

As mentioned above, the results did not support the hypotheses that the mediation is moderated through the habitual use of media in general, the habitual use of age-restricted contents, or the personality trait sensation seeking. This might be because the sample used in this study consisted of university students only. This specific group is probably rather homogeneous with regard to habitual media use and level of sensation seeking. The probability of numerous participants with an extreme and excessive habitual media use or with an enormously high or low level of sensation seeking is therefore rather low. Due to this, the variance of these variables may be restricted, which can lead to smaller or no effects. Hence, further studies on this topic should include a more heterogeneous sample to ensure a broader variance of the relevant measures.

Another critical aspect refers to the measure of habitual media use which was realized by the item “How many hours do you spend in front of the TV / do you play video or computer games on an ordinary day?” and might be too undifferentiated. A more detailed assessment of habitual media use (e.g., separated by weekdays, weekends, and holidays) would be more informative and differentiated. Moreover, beside sensation seeking there may be other personality traits which might play a role in explaining media effects: for example, the need for affect (Maio & Esser, 2002). Need for affect is defined “as the general motivation of people to approach or avoid situations and activities that are emotion inducing for themselves and others” (Maio & Esser, 2002, p. 585). Therefore, people high in need for affect should prefer media contents which are emotionally arousing, whereas people low in need for affect should avoid them. Need for affect might serve as an alternative moderator in the association between media content and cognitive outcomes, instead of sensation seeking.

The strength of this study is the inclusion and differentiation of different media contents and simultaneously of different media types. Other studies usually focus on only one kind of entertainment medium, mostly television. The research on computer games is – due to their technical development – fairly new, and there are many open questions regarding their effects. Further, the attempt to find an explanation for short-term-effects of media contents on cognitive performance enriches the actual state of research, since the findings regarding these short-term processes are very rare. The consideration of possible moderator variables is an important aspect due to the fact that the impacts of media exposure might be differential for different groups of people, as already suggested by others (e.g., Gentzkow & Shapiro, 2006; Schmidt & Vandewater, 2008).

The limitations of this study have partly already been mentioned above. A larger and more heterogeneous sample might yield clearer and more significant results. Moreover, a limited number of possible video games and films was used in this study. Future studies should include a broader spectrum of games and films to achieve more general results. It should further be considered that the high- versus low-arousing conditions used may differ not only in level of arousal and violence but also in other characteristics. The operationalization of the independent variable by two different kinds of content (Doom versus a tennis match) might be problematic because the conditions differ in a lot of other aspects, and therefore the independent variable may be confounded with other characteristics. To mention some of these, the story line, the setting, the background music, and other features are hardly comparable and might ask for different cognitive and motor (in terms of the game condition) skills and operations. Therefore, the effects cannot be reliably attributed to the level of arousal, since there are other possible explanations. Further studies should consider this issue by choosing more comparable conditions. In terms of computer games, it can be imagined, for example, that it would be possible to create different game conditions in one
and the same game. Further, it would be beneficial to consider a larger number of different television programs and video games to obtain a broader generalization.

The games and films used in this study were chosen to ensure parallelized contents for the different types of media. The possible options were limited since there are numerous games without a matching film, and vice versa. Nevertheless, the validation of the different experimental conditions reveals that the high-arousing contents are rated as much more stressful and violent than the low-arousing contents – independent of the type of media – therefore it is legitimate to expect the high-arousing contents to lead to stronger effects.

Another critical aspect is the duration of the media use. In this study, the time interval of media use was kept constant at 25 min, which does not reflect the actual reported duration of watching or playing per day (cf. MPFS, 2009; Roberts, Foehr, & Rideout, 2005). It might therefore be useful to extend this duration in future studies. Finally, memory testing and testing the ability to concentrate were not repeated after a longer time interval. The testing was conducted immediately after the media use. It might be interesting to repeat the testing after a longer period of time (e.g., 24 hours) to be able to analyze the stability of the effects.

In conclusion, this study yields some first results regarding short-term effects of different media contents on cognitive performance, although the underlying explanations have not been completely clarified yet. To further broaden our knowledge about media impacts, it is important to be able to understand the processes explaining media effects and to use this knowledge for prevention and intervention.

References


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