The Merits of Attention Control in Musical Creativity

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Abstract

Previous creativity studies have yielded contradicting results: Creativity seems to benefit from both distraction of attention and attention control. To investigate whether attention control benefits creativity or not, musical creative performance was assessed as a function of Working Memory Capacity (WMC). Thirty-two musicians were first tested for WMC, followed by a recording session of three solo improvisations. These musical solo's were later judged by professionals on their level of creativity. Because WMC allows people to control attention for long periods of time, it was hypothesized that the benefits of high WMC in musical creative performance would increase over time. Indeed results showed that high WMC musicians became more creative over time, while creativity of low WMC musicians decreased over time. Furthermore, individual change in creativity over time was positively related to WMC. Results are discussed in terms of the Dual Pathway to Creativity Model.

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Introduction

Creativity seems to be a mysterious quality restricted to our past geniuses and contemporary greats. Although many associate the term creativeness with artistic achievement, famous scientists and brilliant inventions (e.g. renaissance sketches of helicopters), within the psychological science, scholars tend to agree that creativity is something that lies in mental structures and processes that exist in all of us (see Sio & Rudowicz, 2007; Dijksterhuis & Meurs, 2006; Isen, Daubman & Nowicki, 1987; Amabile, 1983; Dreistadt, 1969; Mednick, 1962). Despite this, there is an ongoing discussion as to which mental structures and processes benefit creativity. Besides the elusiveness of the mental process responsible for creativity, the mere concept of creativity itself is a complex matter. “Psychologists have a long history of disagreement over the definition of creativity, variously defining it in terms of the creative process, the creative person, and the creative product” (Amabile, 1983, pp 357).

The present study focuses on creative performance, assumed to be the reflection of the uniqueness of a creative *product* within the boundaries of a context. The number of creative products that can be generated by one individual within a certain timeframe is usually referred to as creative fluency (Guilford, 1967 as cited in Amabile, 1983). In order to test creative fluency, people are usually asked to list as many creative ideas as possible within a limited amount of time. For example: (a) “Try to come up with as many things to do with a brick”, or (b) “Try to come up with as many ideas to improve the environment”. Creative fluency says something about the quantity of creative ideas, but it is not a sufficient measure of creativity because it is lacking insight into the quality of creativity.

In order to be labeled as creative, a product must also be novel and appropriate within its category. The extent to which a product or idea is in fact uncommon, or infrequent, is labeled as creative originality (Amabile, 1983). Furthermore, the appropriateness (Runco & Charles, 1993), or level of fit to the context is referred to as creative fittingness. The goal of the present study is to investigate which mental processes improve or diminish creative originality and fittingness of a musical product (i.e. creative performance). As stated earlier, there has been quite some discussion about the processes responsible for creative performance. Many assume creative performance to benefit from unconscious, automatic, broad and flexible processing, some argue that conscious attention control, local focus and systematic processing is beneficial to creative performance.

Automatic or Controlled Processing

For both fluency and originality to occur, it is assumed that people need cognitive flexibility. This requires loose processing and the use of many broad cognitive categories (e.g., Förster, Friedman & Liberman, 2004; Mednick, 1962). Research on incubation periods (i.e. taking some time off the creative assignment) has indicated that distracting people from creative tasks temporarily broadens their attention scope, aids broad and automatic processing, and benefits cognitive flexibility (Sio & Omerod, 2009). This indicates that conscious on-task attention might counteract cognitive flexibility. Some authors even argue that creative problems are solved best by unconscious thinking (e.g. Dijksterhuis & Meurs, 2006). Unconscious thinking is assumed to take place during the incubation period, when someone's conscious attention is distracted form the creative task. Dijksterhuis and Meurs (2006) state that 'the unconscious' is much more creative than consciousness. They argue that this difference in creativity is the result of a difference in cognitive capacity between conscious and unconscious thought: The larger processing capacity of unconscious thought allows the unconscious to be more divergent and therefore more creative than conscious thought. This divergence is assumed to foster creative fluency and more importantly: creative originality.

In contrast to the unconscious thought/divergent thought view, Baumeister, Schmeichel, DeWall and Vohs (2007) found that conscious distraction of attention reduced creative aspects of musical improvisation and drawing whereas automatic aspects of performance, such as motor controls, remained unaffected. Additionally, when Baumeister et al. (2007) asked their participants to generate as many creative things to do with a brick, they generated far less creative ideas when their cognitive resources were depleted by a heavy-load cognitive task prior to the brick-task, then when the prior task was cognitively automatic and simple. The authors concluded that conscious attention plays a crucial part in creative idea generation.

Indeed, Segal (2004) found that distracting people during an incubation period was only beneficial for creative problem solving when someone had reached an impasse. If people get stuck thinking in one direction, some distraction from the assignment broadens their spectrum of possible ways to solve the problem, makes them more flexible, and increases chances for creative solutions. If no impasse is reached, there are no incubation benefits.

This raises the question what really happens when creative ideas are generated. Does creativity benefit from broad and automatic processing or from more conscious systematic processing? The view that creativity stems mostly from divergence of thought, or cognitive flexibility, has become dominant in literature. Cognitive flexibility requires that one ‘looks at the broad picture’, or in other words, has a broad or global focus on the creative problem. Research on mood and attention focus/processing modus has repeatedly linked positive moods to global/broad focus, whereas negative moods are perceived to foster a localized/systematic focus (Frederickson & Branigan, 2005; Gasper & Clore, 2003). Creative problem solving is found to be facilitated by positive mood because positive mood allows broad processing (Isen, Daubman, & Nowicki, 1987), and abstract creativeness has been linked to a global/broad attention focus (Förster et al. 2004). This makes it tempting to assume that people who relatively focus more local and process systematically are also less creative. However, De Dreu, Baas and Nijstad (2008) have recently argued that in addition to cognitive flexibility, creative fluency and originality can also be achieved by working hard, deliberately trying to be persistent, and thoroughly exploring only a few cognitive categories or perspectives and elaborating on creative ideas.

Dual Pathway to Creativity Model

The Dual Pathway to Creativity Model (De Dreu et al. 2008) states that there are two cognitive routes that can be taken to generate a creative product. According to the authors, creative performance can be influenced either by (1) cognitive flexibility: fast and relatively effortless skipping through a large number of broad categories, or by (2) persistence and perseverance: systematically scanning cognitive categories, using prolonged effort and time to creatively explore a smaller number of categories. Through perseverance, one cognitive category is thoroughly scanned for creative possibilities before moving to the next category. Evidently, it is equally possible to come up with a large number of ideas within a few categories by systematic thorough searching as it is possible to generate many ideas by skipping through many categories fast and fleetingly. Effortful scanning of one or few categories might lead to uncommon and infrequent ideas, because one thinks beyond the easily accessible category representatives.

Contradicting the assumption that a broad processing style and a positive mood is necessary for creative originality to occur, De Dreu et al. (2008) showed that negative activating moods (such as anger) can lead to the generation of more unique ideas through enhanced cognitive perseverance and persistence. Creative idea generation can thus benefit from more localized, within category information search.

Creative Fittingness

Another important question is whether divergent thought is always functional when generating a creative idea. It might be functional when the task demands many different solutions or ideas from different categories, and if one is only supposed to perform creatively for a short period of time. But what will happen when global ideas need to be further elaborated in order to put the creative idea into practice?

As stated earlier, a product must both be novel and fitting to the context. An idea can be very original, but if it is not functional, it can hardly be called creative. In the case of the brick-example (i.e. “Try to come up with as many possible things to do with a brick”), a creative idea would be fitting if the action in fact involves a brick and if the action produces benefits (i.e. is functional). It might be relatively easy to think of something really odd (and original) to do with a brick, like using it for juggling. But when you have to come up with something that is both novel and fitting, further elaboration is desired. If you think a little further about juggling with bricks you would probably conclude that this would not produce any benefits, with the potential drawback of increasing the risk of injury. Generating new ideas is just one step in the creative processes. Finding something that really works is a necessary and challenging process that can lead to a truly creative product.

Furthermore, creative fittingness should benefit from a more persistent within category search. Consciously elaborating on ideas might lead to ideas that are both original and fitting to the situational demands. Since perseverance can be explained as the ability or the motivation to thoroughly explore and elaborate on ideas, it would be beneficial to be able to control conscious attention for long periods of time. In order to do this, one needs the mental capacity to keep conscious attention focused on a creative task.

Attention Control and WMC

According to Kane and Engle (2003), attention control is central to working memory. Working memory is a system that manages to monitor conflicts between task goals, external stimuli, and automatic response patterns. The function of working memory (WM) is to keep task-relevant information active in short term memory, while manipulating this information and new incoming stimuli to perform a task. “WM is the system responsible for holding information available for complex cognitive activities such as language comprehension, planning, and reasoning – all those activities that involve the representation and processing of how two or more elements are related to each other” (De Dreu, Nijstad, Baas & Roskes, submitted). Complex WM tasks have simultaneous storage and processing components. During these tasks, participants are tested on the number of items that can be recalled after storing them in WM for a short period of time (Feldman, Barret, Tigade & Engle, 2004). The number of items that can be stored in WM is used to represent Working Memory Capacity in people. As argued below, it is assumed that the ability or capacity to control attention grows with working memory capacity (WMC).

Kane and Engle (2003) examined conflict of habitual (automatic) responses and task goals with the Stroop-task (Stroop, 1935; Kane & Engle, 2003). During this task people report the printed colors of words which are presented on a computer screen. This is relatively easy and responses quickly become automatic. To create cognitive conflict, some words in the task are color words representing a different color than the color in which the word is printed (for example, the word *green*, printed in *red*); participants then have to inhibit their automatic response to report the color they read, instead of the color they see. Kane and Engle (2003) found that people with low WMC showed more goal neglect (the goal being to report the color they see) than people with high WMC. High WMC's were more able to block the distraction of the incongruent color words, and to solve the cognitive conflict that the color incongruence caused. The authors concluded that active goal maintenance and distractor blocking are central to WMC.

According to Barret, Tugade and Engle (2004), behavior is determined by the interplay of automatic and controlled processing. Sensory properties of objects in the environment capture attention. The 'cocktail party effect', which was reexamined by Conway, Cowan and Bunting (2001), is a good example of unintentional capture of attention. The cocktail party effect refers to the phenomenon of a sudden switch of attention from for example, a conversation at a cocktail party, to another important stimulus, like ones name. Humans can only focus conscious attention on one thing at a time, and most people will automatically switch attention from their primary focus to the other stimulus, the name. When Conway et al. (2001) divided their subjects into two groups on the basis of WMC, they found a difference in the ability to control attention to stay on the primary message despite of the distraction of ones name. People with high WMC were able to ignore the calling of their name in their secondary ear (channel) 80 % of the time, while only 35% of people with low WMC were able to stay focused on the message in the primary channel and ignore their name. From these results it seems that it is relatively easier for people with high WMC to stay focused on one task than it is for people with low WMC.

In agreement to this view, McVay and Kane (2009) found that low WMC participants experienced more ‘mind wandering’ (task irrelevant thoughts) during the creative tasks. Moreover, people with high WMC were better at suppressing automatic responses. Low WMC’s not only showed more goal neglect, but also less controlled attention than high WMC participants.

Since WMC is assumed to be central to attention focus and executive control, defining the relationship between WMC and creativity can reveal whether creative performance benefits from attention focus and executive control or not.

Musical creativity and attention control

This study will specifically focus on musical creativity in relation to WMC. Chaffin, Lemieux and Chen (2006) state that *to be creative in musical performance is to be able to express freshness and spontaneity in a musical piece*. A performance’s freshness and spontaneity is generated through closely monitoring the musical aspects and keeping ones goals in mind – all while highly trained and automated motor responses create the sound itself. This is where WMC is hypothesized to come into play. According to Chaffin et al. (2006), creativity depends on what the musician is thinking during performance. If a musician is not paying attention to the musical goals, his or her performance will be automatic and boring. Since control of attention and goal attainment seem to be easier for people with high WMC, it is plausible to assume that differences in WMC produce variations in musical creativity, especially in the longer run.

To get at the creative aspect of music in the present study, we asked musicians to improvise based on several assignments. According to Biasuti and Frezza (2009), musical improvisation involves a plan, and anticipation to environmental context. Professional musicians state that the most important requirement necessary for successful improvisation is the anticipation of musical events, in other words, thinking ahead. This is a procedure that needs cognitive effort involving long-term foresight of the development of the whole solo. It would be impossible for improvisation to be a fully unconscious or automatic process, because anticipation is a conscious activity, involving cognitive effort. It allows the improviser to find very complex, creative solutions which are elaborated and used, making the improvisation sound innovative, instead of repetitive and automatic. In Biasuti and Frezza's (2009) qualitative investigation, professional musicians describe the ultimate state of creativeness as a state of flow. A state of flow is present when the improviser concentrates only on the performance, being fully consciously focused on the creative moment. Biasuti and Frezza (2009) found a correlation between anticipation and flow, indicating that high levels of concentration while being in a state of flow might enhance the accuracy of anticipation and the generation of a creative performance. All concentration, monitoring and anticipation needed to make the improvisation work should benefit from a capacity to focus attention and therefore require high WMC.

Problem and Hypothesis

De Dreu et al. (2008) already showed that creativity can also be attained through persistence and perseverance. Furthermore, De Dreu, Nijstad, Baas and Roskes (2010), found that higher WMC is positively related to creative fluency and originality because of enhanced persistence and not because of enhanced cognitive flexibility. This means that a localized conscious attention focus can be functional to creativity. Of interest is Heerebout and Phaf's (2010) argument that good mood does not exclusively aid global attention focus, yet it facilitates shifting between global and local focusing, using either of the two strategies when necessary. Presumably WMC works in a similar manner: people with high WMC are better at localizing attention, and suppressing other stimuli. But since suppression is a controlled and functional action serving the task demands, it can be argued that high WMC people can also choose to allow more stimuli into their mind, or include more categories in their information search - if this would be functional to the task demands or goals. Therefore, people high in WMC are not necessarily less cognitively flexible than people with low WMC, but they are more persistent, and therefore more creatively original and provide more creative fittingness over long periods of time.

Within the Dual Pathway to Creativity Model it is hypothesized that there are two routes to creativity, namely an automatic route of cognitive flexibility, and a controlled systematic route of persistence. Furthermore, WMC is hypothesized to allow people to use the persistence route. Persistence is, amongst other factors, assumed to be the result of keeping ones conscious attention upon the problem at hand for long periods of time, while blocking irrelevant or conflicting stimuli from interfering with the task demands. Our hypothesis is that through conscious effort and persistence, creative originality and creative fittingness can be fostered. Since people with high WMC seem to be good at consciously guiding attention, staying focused on their goals, blocking irrelevant information and experience little task irrelevant mind-wandering, they should be able to use this capacity to be persistent in their musical performance. Creative originality and creative fittingness of musical improvisations is therefore assumed to grow as a function of time only for people with high WMC. If this hypothesis is incorrect, and creativity is mostly a function of the distracted, cognitively flexible mind, WMC should have no or negative impact. However, when persistence and conscious elaboration is also involved, attention control and WMC should benefit creative performance.

Since people with low WMC have problems concentrating on task demands as time passes, we expect creative originality and fittingness of lower WMC-participants to decrease over time. Differences in creativity between people with high and low WMC will therefore become more evident when the time musicians have spent on-task focused is longer. In other words, we expect that people with high WMC outperform people with low WMC in creative tasks over long periods of time.

Participants played three different musical improvisations. Creative originality and fittingness of low WMC musicians was expected to be highest on the first improvisation, and lowest on the third. The pattern of creative performance for high WMC musicians was expected to be reversed: Originality and fittingness scores should be highest in the last improvisation due to persistence. Since cognitive flexibility is assumed to be less influenced by conscious attention focus, there was little to no difference in cognitive flexibility expected as a function of time and WMC.

Method

Design and Participants

Participants were cellists (*N*=32, 68.8 % women, 31.2% men), playing either on a high recreational level or in the pre-course of the Conservatory of Amsterdam (*N*=16), or studying the instrument on the Conservatory of Amsterdam, Utrecht or Rotterdam (*N*=16) in all years of enrollment. Their experience on the instrument ranged from 8 to 20 years (*M*= 13.06 *SD* = 3.33. Fourteen participants reported to have some experience in improvisation which was mostly at their own initiative and not formally provided in the conservatory program. The remaining 56 % reported having no experience whatsoever in improvising. Hence, the players were sufficiently skilled to craft a musical performance, but none of them were formally trained in the art of improvisation. Dutch language proficiency (reading & writing) of all participants was sufficient for the WMC task that was used to measure the independent variable WMC.

The dependent variable was Creative Performance, of which different aspects were measured. Creative Performance was divided into three categories, namely (1) Creative Originality as reflected in: creativity of variations, originality of the idea, creativity of the idea and original development of the improvisation, (2) Creative Persistence and Goal Maintenance as reflected in: the wholeness of the improvisation, musical communication of the impression as prescribed by the assignment, and impressiveness of the implementation of the assignment, and (3) Cognitive Flexibility as reflected in: variation in dynamics, variation in tempo, variation in articulation, variation in bowing technique and variation in musical themes.

Procedure, Tasks, and Measures

All participants were first tested on Working Memory Capacity. The assessment of WMC took place in a different session than the assessment of creative performance, with two to four weeks between measurements. Their creative performances were later judged by two independent judges, in terms of the criteria outlined above. These judges were professional cellists with many years of experience in performing and teaching at a high level.

Independent Variable: Measuring WMC

WMC was measured for each participant separately. The experimenter visited the participant either at home or at school and administered the Working Memory Capacity test on a laptop in a quiet room. All participants received an oral explanation of the test, and the experimenter was present in the room while they took the test. Working Memory Capacity was measured by means of a delayed serial recognition task (Roisson & Pourtois, 2004, as cited in De Dreu, Nijstad, Baas & Roskes, 2010). Participants performed a series of 46 trials. On each trial participants were presented with eight words that appeared sequentially in the center of the laptop screen. Each stimulus remained on screen for 0.25s. After a series of eight stimuli, the screen went blank for 1s during which participants had to keep all information in memory. Following this “maintenance interval” they were shown a single word. As a response to this last target stimulus, they had to indicate whether they had seen it in the previous series of eight stimuli, or not. In other words: is the target stimulus (1) a new stimulus, which has not appeared in the previous series, or is it (2) an old stimulus, which has appeared in the previous series. Fifty percent of the 8-word series were followed by an old target stimulus (no-change trials). The other fifty percent of the series was followed by a new target stimulus, which was different from the previous eight trials (change-trials). These new target stimuli were randomly drawn from a set of 130 possible items. Change versus no-change trials were presented randomly. For each set we assessed response accuracy with a perfect WMC score of 46 (Jha & McGarthy, 2000; Ranganath, DeGutis, & D'Esposito, 2003). Performance motivation was tested at the end of the WMC task by means of a 5-point scale questionnaire (1 = not at all, to 5 = very much).

Dependent Variable: Measuring Creative Performance

The Creative Assignment

Participants were asked to generate several musical improvisations on their instrument. These improvisations were recorded in a professional studio of the Conservatory of Amsterdam, under supervision of a professional audio engineer. All cellists played their improvisations based on three assignments, which they received in random order. Time to improvise was fixed at three minutes per assignment. Before each improvisation, participants got one minute to generate creative ideas based on the assignment. As soon as this minute was over, the audio engineer started the recording and repeated the assignment and the timeframe out loud. This was the signal for the players to start their improvisation. Ten seconds before the end of each improvisation, participants got an aural cue (which was practiced before their improvisations started) allowing them to creatively finish their solo – instead of just cutting of the performance.

Participants were seated in the middle of the studio facing the side wall. Instructions about the number of assignments and the different timeframes were given to them by the experimenter. After the experimenter left the studio, the audio engineer vocally guided them through the assignments. The total recording session took about 12 minutes, of which nine minutes were used for improvisation.

The Musical Creativity Scale

After the improvisations were recorded, they were all scored by independent judges by means of a creativity scale which was especially designed for musicians. As argued in the introduction, an idea is creative when it is original, as well as appropriate, which means it has to be fitting to the situational demands. In this specific situation, participants should be inventive and original in their improvisation ideas, but also attend to the assignment and carry out their musical communication of the idea all the way to the end of the improvisation in order to get high creativity scores. Therefore, the Musical Creativity Scale was build to grasp creative originality as well as creative fittingness. Furthermore, a subscale for cognitive flexibility was designed in order to check whether time had any influence on the use of category fluency to be musically creative. Table 1 (Appendix) provides an overview of the Musical Creativity Scale including reliability statistics. All items were scored on a 5-point scale, with value 1 representing the lowest score and value 5 representing the highest possible score.

Before the actual process of rating improvisations started, a sample of 10 improvisations was chosen from the whole set in order to determine inter-judge reliability. Inter-judge reliability was computed with Pearson's *r* over all improvisations and was good for all subscales (Creative Originality $r = .75$, $p < .001$; Creative

Fittingness $r = .83$, $p < .001$; Cognitive Flexibility $r = .77$, $p < .001$). The reliability of the total Musical Creativity Scale was extremely high (Cronbach's $\alpha = .97$), as was the reliability of all sub-scales (α Creative Originality = .96; α Creative Fittingness = .93; α Cognitive Flexibility = .93).

Results

WMC-scores

Correlations between WMC and the dependent variables indicated that higher WMC became beneficial as time passed. Both creative originality and creative fittingness showed a negative correlation with WMC on the first assignment, which diminished at the second trial, and disappeared at the third one. Interestingly, a negative correlation between cognitive flexibility and WMC was found, which remained stable over trials. Correlations for all three assignments between WMC and creative originality, creative fittingness and cognitive flexibility, see Table 2 (Appendix).

To further investigate interactions between WMC and time, two groups were created with a median split in WMC score. All participants in the low-WMC condition had a total score of 40 correct items or less (N=17), the high-WMC Group was composed of participants with a WMC-score higher than 40 (N = 15).

Creative Originality

Creative originality of the first, second, and third trial was submitted to a 2 (High/Low- WMC) * 3 (Trial:$1^{st}/2^{nd}/3^{rd}$) Analysis of Variance, with the second factor within-subjects and years of instrument experience as a control variable. Results showed an interaction between WMC and Trial, $F(2, 60) = 6.21$, $p < .001$. As can be seen in Table 3 and Figure 1 (Appendix), high-WMC participants became more creatively original over time, $F(2, 60) = 3.26$, $p < .05$, while low-WMC participants became less creatively original over time, $F(2, 60) = 3.13$, $p < .05$. This WMC * time interaction supports the idea that WMC is beneficial for a persistent route to creative originality because the influence of persistence grows with time.

Creative Fittingness

Creative fittingness scores were similarly submitted to a 2 (WMC) * 3 (Trial) Analysis of Variance. As with creative originality, results showed an interaction between WMC and Trial, $F(2, 60) = 3.69$, $p < .05$ (See Table 3 & Figure 2, Appendix). An additional paired t-test showed that creative fittingness scores of low-WMC participants decreased between the first and the last Trial, $t(16) = 2.23$, $p < .05$. The increase in creative fittingness in the high-WMC group over trials was marginally significant, $t(14) = 1.63$, $p = .06$.

The interaction between time and WMC and the decrease in fittingness for low-WMC participants supports the assumption that consciousness and attention focus is beneficial to generate ideas that are fitting to situational demands. The increase in fittingness of high WMC participants suggests even that their ideas got more functional and fitting over time.

Cognitive Flexibility

Results of a 2 (WMC) * 3 (Trial) Analysis of Variance showed no significant interaction between WMC and Trial for cognitive flexibility. Flexibility scores of both WMC groups remained stable over time as can be seen in Table 3 and Figure 3 (Appendix). No differences in cognitive flexibility were found between WMC groups. This supports the assumption that high WMC musicians are not necessarily less flexible than people low in WMC. Furthermore, since time had no effect on flexibility scores, it seems that cognitive flexibility is a route that does not require effortful processing and therefore does not require high WMC.

WMC and Linear Change in Creative Performance

It is assumed that high WMC supports the persistence pathway because it allows conscious on task attention focus over long periods of time. Without high WMC, it should be difficult to be persistent, resulting in decreasing creativity if conscious attention focus indeed benefits creative performance. Therefore, it was expected that over time, cellists low in WMC would show a decrease in originality and fittingness, whereas originality and fittingness of high WMC cellists would increase and flexibility would remain stable. The 2 * 3 Analysis of Variances already proved these expectations to be correct at the group level. Nevertheless, it was decided to use a more sophisticated analysis to further define the relationship between WMC and individual creative performance. Since it was hypothesized that an increase or decrease in originality and fittingness over trials depends on WMC, a linear change in originality and fittingness within subjects should correlate with WMC. As WMC was not hypothesized to influence flexibility, there should be no correlation between linear change in flexibility within subjects and WMC.

Linear change in originality, fittingness and flexibility was assessed with an individual regression analysis trough all points of measurement (Trial:1st/2nd/3rd). For each participant, the standardized regression coefficient (β) was used to represent linear change in originality, fittingness and flexibility. As expected, linear change in both originality and fittingness correlated positively with WMC (originality: $r = .35$, $p < .05$;

fittingness: $r = .33$, $p < .05$) and linear change in flexibility did not (see Table 4 for all correlations). This additional analysis further strengthens the assertion that WMC benefits creative performance through a persistence pathway, and not through a flexibility pathway.

Discussion

Results of this study show that working memory capacity benefits creativity because it allows an effortful, conscious, and controlled generation of ideas. Whether conscious processing helps creativity or not depends on the timeframe. The ability to consciously focus on a creative task benefits creative performance more as time passes. This attention focus ability not only allows people to perform creatively for longer periods of time, it also tends to increase quality of creative performance over time. This assumption is supported by the data which show that creative originality as well as creative fittingness of musical improvisations grew with every improvisation only for people high in WMC. This supports the hypothesis that people high in WMC use a more persistent route to creativity, allowing a deeper and thorough search within a category. Meaning that ultimately, the most uncommon category representative and the most elaborated and fitting idea, will be generated last in time. Hence: Originality and fittingness of the last assignment should be highest for these high WMC cellists, as was supported by the results.

Not only were the cellists high in WMC more persistent, the cellists low in WMC showed a decrease in originality and fittingness. Since previous research (McVay & Kane, 2009; Kane & Engle, 2003) has shown that people low in WMC have trouble staying focused on a task, it is assumed that the drop in originality and fittingness for low

WMC participants was a result of their inability to stay focused on the task. This supports the hypothesis that conscious on-task processing is not just beneficial, but necessary if one has to perform creatively for long periods of time.

Furthermore, since cognitive flexibility was unaffected by time and no between (WMC) group differences were found, there is no reason to assume that high WMC impairs the ability to be cognitively flexible. This also supports the hypothesis that cognitive flexibility is a route to creativity that is not related to controlled attention, but fostered by automatic and less controlled processes which require less cognitive effort and resources and are therefore less affected by time. Contrary to suggestions in literature that creative originality is mostly fostered by cognitive flexibility, this study shows that cognitive flexibility is not the only way to be creative and that cognitive flexibility alone is not sufficient to stay creative over time. Low WMC participants showed no decrease in cognitive flexibility, while their originality and fittingness did decrease over time. Cognitive flexibility might be useful in the beginning of idea generation, but as time passes, creative originality and fittingness might be best reached through persistence, which is supported by high WMC. This indicates that conscious attention control plays a crucial role in creative musical performance.

It is concluded that there are two routes to creativity, namely (1) cognitive flexibility – automatic, broad – and (2) cognitive persistence – controlled, attention focused. Since no between group difference in cognitive flexibility was found, it is possible that people high in WMC have the luxury of being able to use both routes. As stated in earlier, it might be that high WMC people are better in shifting between strategies, just like people in positive moods were more able to shift between broad/global and local focus (Heerebout en Phaf, in press). Could it be that people in a positive mood need less cognitive resources to deal with their negative moods and hence have more WMC to attend to an assignment at hand? Results from De Dreu at al. (2008) on activating moods vs. deactivating moods suggest that only activating moods (both positive and negative) benefit creativity. Indeed, research on depression (de-activating mood) and WMC suggests that people with depression are impaired in WMC and that the central executive control component is most affected by depressive symptoms (Arnett, Higginson, Christopher, Voss, Bender, Wurst, & Tippin, 1999). People probably need motivation to use their WMC (activating mood), as well as the cognitive energy to be able to use it (not being de-activated). De-activating moods might interfere with WMC through motivation as well as depletion and distraction of attention, which is why creativity is also impaired. Whether impairment of WMC is in fact the reason that deactivating moods do not foster creativity is something that warrants further investigation.

Study Limitations and Future Research

An obvious limitation of this study is the small sample size. However, this did not prevent all predicted patterns of results from being found. A larger sample size is recommended such that the conclusions may be strengthened. Further, this would allow the design and testing of a multilevel model of creativity including flexibility, persistence and WMC as well as other possible indicators of creative performance, such as experience on the instrument.

Another point of note is the sample type that was used. This study investigated creative performance among classical musicians who had reported very limited improvisation experience. Musicians who have been enrolled in classical musical programs are usually first to claim that during formal classical education at the conservatory, all creativity is lost. This assumption is born from the belief that in order to be creative, you need to be as unrestricted (and cognitively flexible) as possible, and that formal systematic training impairs this flexibility. Because in classical music education, musicians are trained to play the same musical peace over and over again, elaborate on the same bars repeatedly and work systematically to enhance their performance, it is tempting to assume that this impairs originality. Evidently, if originality would only be fostered by automatic, broad and flexible processing, such an education would not aid creativity. However, as this study has shown, conscious controlled processing is equally important if not more important to originality, especially when time is involved. Within this study musicians had to stay focused for 12 minutes which was long enough for the creative originality of low WMC cellist to drop. Most musical performances last much longer than 12 minutes, which highlights how important it is for musicians to be able to stay focused on the creative development of their performance. The claim that classical music education spoils creativity in players also overlooks the importance of being able to find ideas that are both fitting to the problem and novel, as opposed to just being novel. Being able to elaborate on a musical idea requires a deeper understanding of the rules of music. In order to be creative with rules, one first has to know them. And in order to execute this knowledge, one has to master the technical skills of the instrument so there is no need for focusing on technique while putting ideas into practise. It can be argued that people who are trained in musical structures and instrument skill, have a very different approach to creativity which is more systematic than the approach of people who do not posses these qualities and who are therefore more bound to use an automatic flexibility route.

Research on perceptual and memory differences between groups of chess players of different level of skill has shown that a trained mind organizes information in a different way than an untrained mind. Training allows people to chunk information, allowing much more information to be kept active in working memory (Chase & Simon 1973). Presumably, trained musicians operate in a similar manner. Being able to keep more information active during an improvisation enables the musician to return to previously played themes, make multiple variations on one theme, and use musical themes from memory to combine them with their new idea. This should all be beneficial to a creative product that is original as well as a unity, and fits the context. It would be very interesting to investigate how training in music in general as well as instrument skill and training in improvisation affect the mental strategies people use to be creative. It could be argued that musical training, as well as improvisation and instrumental training would enhance the ability to be persistent and process systematically, because all of the above enhances the WMC that can be used for creative performance. Understanding musical rules aids musical elaboration; training in music and improvisation allows chunking of information; and instrumental skill allows playing to be automatic, thereby allowing consciousness to be devoted to the creative performance. Further research could show whether these assumptions hold true by including classical musicians, jazz musicians, or other improvisation musicians of severely different level of skill.

Creativity remains a concept that is ‘in the eye (or in this case, ear) of the beholder’. Although the creativity scale was very reliable, there were still differences in creativity scores between judges. Evidently, people differ in their opinions of what is creative and what is not. This appoints the need for multiple judges and a re-evaluation of the musical creativity scale with more judges of different kinds of musical disciplines if this scale should be used in future research.

Concluding thoughts

Creativity researchers have long argued that creativity is fostered by unconscious, automatic and broad processing. While the results of this study do not demonstrate that an ability to engage in unconscious, automatic and flexible processing hurts creative performance, they do show that an inability to control conscious attention undermines creative performance. This shows the importance of conscious attention control and supports the conclusion that there is a Dual Pathway to Creativity. These conclusions were already supported by previous research with creative insight tasks and creative idea generation in brainstorming tasks (De Dreu et al. submitted; De Dreu et al. 2008) and they are now supported in an additional dimension of creativity, namely the art of music.

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Appendix

Table 1: Musical Creativity Scale (Crohnbach's α =.97): Items and Sub-scale Reliabilities

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Creative Originality (Crohnbach's α =.96)

- *Originality of the idea*

  . Did the participant use an original idea for his/her improvisation?

  Creativity of the idea

  . Did the participant use a creative idea for his/her improvisation?
- *Creative development of the improvisation*

  . The improvisation was developed in an original way…
- *Creativity of variations on the idea*

  How creative were the variations/themes within the idea?

*Creative Fittingness (*Crohnbach's α =.93)

- *Wholeness of the improvisation*

  Was the improvisation a whole?
- *Musical communication*

  Did the improvisation communicate the right association as prescribed by the assignment?
- *Impressive implementation of the assignment*

  Was this association communicated in an impressive way?

Cognitive Flexibility (Crohnbach's α =.93)

- *Variation in dynamics*

  To what degree did the participant use: Differences in dynamics
- *Variations in tempo*

  To what degree did the participant use: Differences in tempo
- *Variations in articulation*

  To what degree did the participant use: Differences in articulation
- *Variations in bowing technique*

  To what degree did the participant use: Different bowing techniques
- *Variations in themes*

  Were multiple variations or themes used?

Table 2. Correlations between WMC and Originality, Fittingness and Flexibility

				Creative Originality			Creative Fittingness			Cognitive Flexibility		
	Trial			1	2	3	1	2	3	1	2	3
WMC				-.37*	-.07	-.01	-.28	-.15	.08	-.34*	-.14	-.32*
		M	SD									
Creative Originality	1	2.83	.82	1	.60**	.61**	.86**	.49**	.35*	.88**	.43**	.52**
α= . 96	2	2.86	.63		1	.58**	.41**	.85**	.55**	.53**	.75**	.53**
	3	2.80	.55			1	.66**	.52**	.78**	.52**	.39*	.64**
Creative Fittingness	1	3.35	.73				1	.40*	.47**	.76**	.38*	.46**
α= . 93	2	3.40	.59					1	.58**	.41*	.79**	.44**
	3	3.35	.70						1	.26	.44**	.36*
Cognitive Flexibility	1	2.26	.62							1	.42**	.65**
α= . 93	2	2.35	.58								1	.44**
	3	2.28	.52									1

Note: *N*=32, * *p* <.05, ** *p* < .01

Table 3.. Mean Originality, Fittingness and Flexibility scores of Low- and High WMC groups.

		Creative Originality		Creative Fittingness		Cognitive Flexibility	
WMC	Time	M	SD	M	SD	M	SD
Low	1	3.05	.81	3.48	.75	2.35	.67
High		2.60	.77	3.21	.71	2.16	.56
Low	2	2.80	.49	3.43	.54	2.31	.62
High		2.90	.78	3.39	.66	2.39	.55
Low	3	2.71	.60	3.19	.72	2.27	.52
High		2.91	.53	3.54	.64	2.30	.53

Note: N = 32 N WMC Low = 17 N WMC High = 15

Table 4. Correlations between WMC and linear change in Originality, Fittingness and Flexibility over 3 blocks

Linear change in	Originality			Fittingness			Flexibility		
	r	*p*	*N*	*r*	*p*	*N*	*r*	*p*	*N*
WMC	.35	.02*	32	.33	.03*	32	-.01	.48	32

Note: * p <.05, 1-sided

Figure 1. Mean Creative Originality scores of Low- and High-WMC groups.

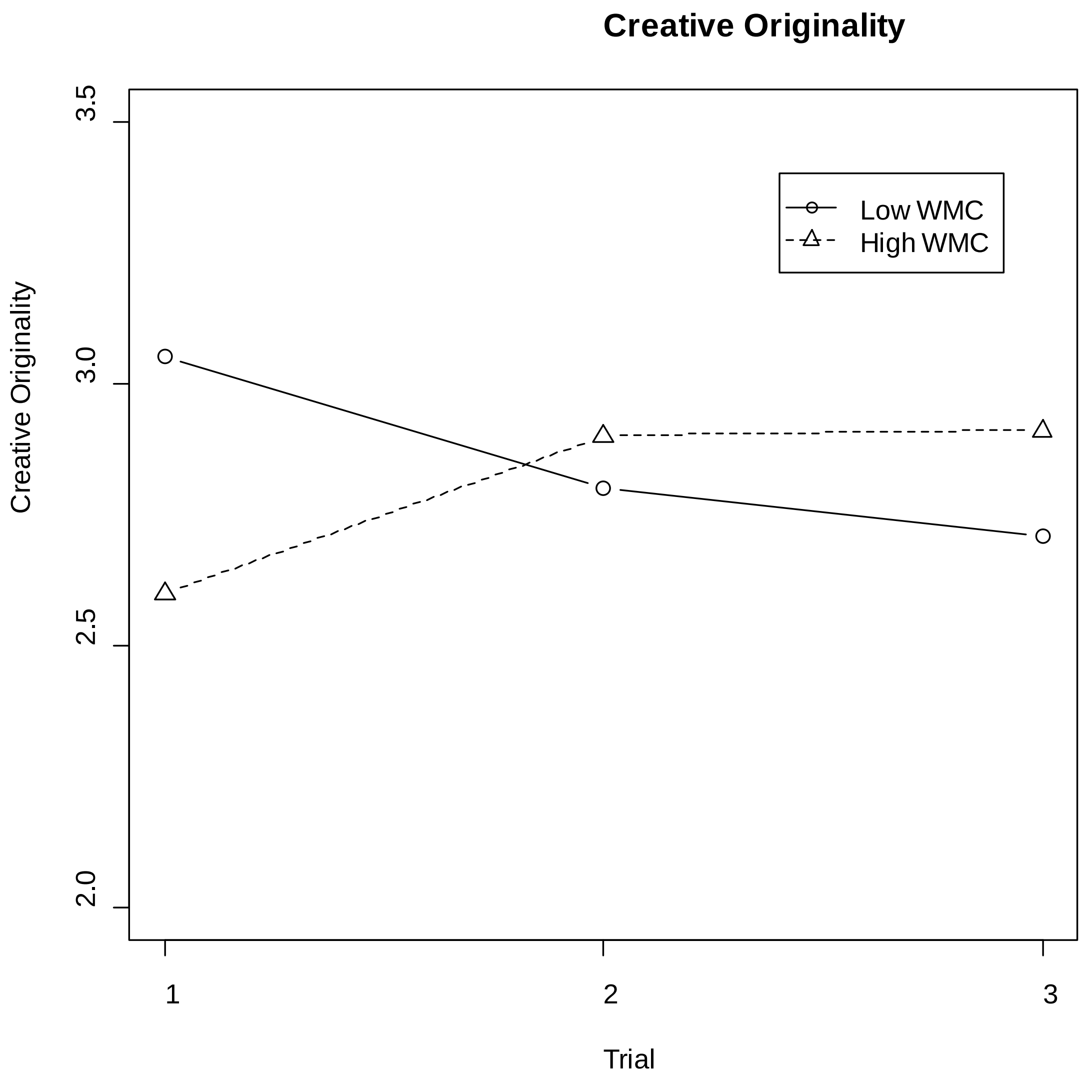

Figure 2. Mean Creative Fittingness scores of Low- and High-WMC groups.

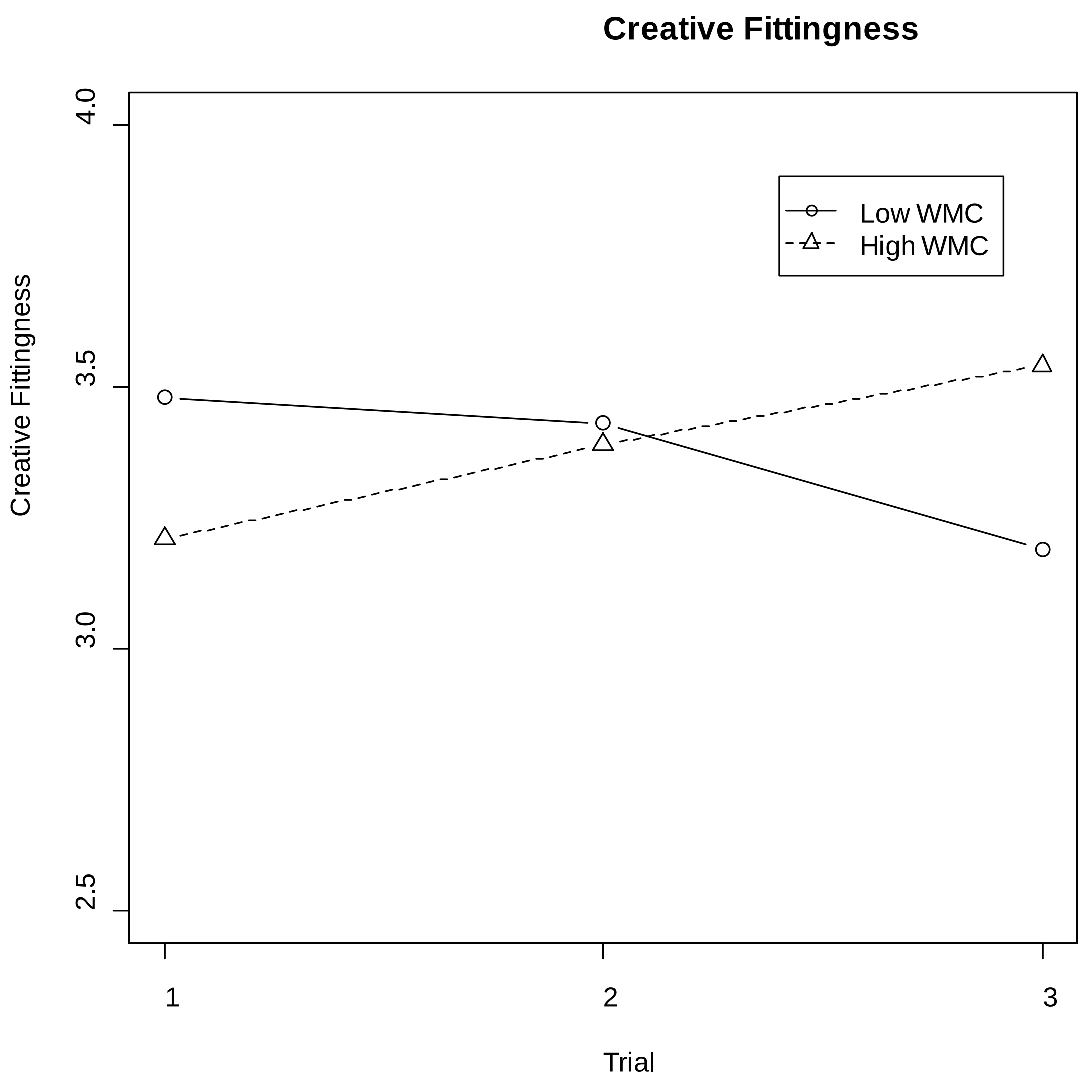

Figure 3. Mean Cognitive Flexibility scores of Low- and High-WMC groups.