Persisting Through Difficult Tasks: Individual Differences in
Working Memory Capacity and Explanatory Style

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Explanatory Style

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Throughout our daily lives, we encounter various tasks that are frustrating and require persistence to complete. However, this ability to persist varies among individuals with some persisting longer than others, and both cognitive and personality variables are likely to jointly influence this ability. In this study, participants performed a laboratory based persistence task involving unsolvable puzzles. Contrary to prominent self-control theories, results indicate that pure ability (e.g., working memory capacity; WMC) alone is not related to persistence. The relationship between WMC and persistence depends on the explanatory style (how people typically interpret the cause of events) of individuals. For those with an optimistic explanatory style, high WMC is associated with more persistence, whereas, for those with a pessimistic explanatory style, high WMC is not associated with more persistence. In other words, to be among those who persist longer, it is necessary to have both a high WMC and an optimistic explanatory style. This research suggests that it is important to consider multiple factors when exploring the tendency to quit while performing frustrating and difficult tasks.

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CHAPTER I

Introduction

We are very often presented in our daily lives tasks that are difficult and require persistence. With the difficulty some college students have in getting to class everyday (only 53% of students graduate within six years; Marklein, 2009) and how difficult it is for smokers to quit smoking (30% of all cancer deaths are attributed to smoking; CDC, 2005), it is clear that persistence in reaching goals is a serious issue. However, we do see variability in the population with some being able to persist better than others. So, exactly what characteristics lead to these failures in persistence? Although the topic of persistence and self-control has gained popularity over the recent years, it is rarely explored from the perspective of cognition and individual differences. The purpose of the current research is to examine, from the perspective of individual differences, how cognitive and personality variables interact to predict how long individuals persist on frustrating and unsolvable tasks.

Brief Review of Prior Persistence Research

Measures of persistence have generally consisted of questionnaires and intellectual tasks in the laboratory. For example, Lufi and Cohen (1987) found that their Persistence Scale for Children (among young gymnasts) effectively predicted those who dropped out and differentiated gymnasts from nongymnasts. Three subscales within the College Persistence Questionnaire (institutional commitment, academic integration, and academic conscientiousness; Davidson, Beck, & Milligan, 2009) have been shown to be predictive of college freshmen returning as sophomores. There are also related measures of grit and self-control that include items such as “I often set a goal but later choose to pursue a different one” (Grit-S; Duckworth & Quinn, 2009) and “I am good at resisting temptation” (Self-Control Scale; Tangney, Baumeister,

& Boone, 2004). Although these studies explore individual differences in persistence, they rely on the self-report of participants and lack a direct measure of persistence.

Within the laboratory, difficult or unsolvable intellectual tests have typically been used. These have taken the forms of difficult to unsolvable anagrams (e.g., Dvorak & Simons, 2009) or the cold pressor task, which involves placing one's hands in ice-cold water (e.g., Vohs et al., 2008). Other investigations into persistence in the laboratory used unsolvable geometric tracing puzzles. Originated by Glass, Singer, and Friedman (1969), these geometric figures must be completely traced without retracing any lines and without lifting the pen from the paper. Unbeknownst to the participant, these puzzles are mathematically unsolvable.

Performance on these tasks is usually explored from a self-regulation perspective. They are often categorized as self-control tasks in that they require the inhibition of the automatic tendency to quit when frustrated (Vohs et al., 2008). Here, inhibition ability is considered to be the main contributor to persistence. This perspective has been generated primarily due to ego-depletion experiments that assume a strength model of self-control (Baumeister, Vohs, & Tice, 2007). The strength model hypothesis proposes that exercising control over emotions, thoughts, and impulses draws from a common internal resource bank and is analogous to a muscle being fatigued after use. Therefore, after an initial act of self-control, participants will perform worse on a second act of self-control suggesting that both tasks draw from the same self-regulatory resource bank (Baumeister, Bratslavsky, Muraven, & Tice, 1998).

For example, a decrease in persistence on unsolvable puzzles occurred for those who initially performed an act of self-control such as the Stroop test (Wallace & Baumeister, 2002). Because the Stroop test, which is regarded as an act of self-control, had a depleting effect on performance during the persistence task, persistence is also assumed to be an act of self-control

and draw from the same resource bank. Solberg Nes, Carlson, Crofford, de Leeuw, and Segerstrom (2011) similarly observed a decrease in persistence on an unsolvable anagram for participants who previously inhibited reading words on a screen while watching a movie compared to participants who merely watched the movie.

However, there are concerns common across these studies that should be highlighted. First, the criteria for self-control in this literature can be quite vague. The term self-control (or self-regulation) is often stated as effortful control with the emphasis on the effortful component (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Therefore, any task requiring effort is seen as self-regulatory persistence because it presumably elicits the tendency to quit that must be inhibited. This allows there to be a multitude of alternative explanations for the ego-depletion effect such as an increase in general fatigue, a decrease in motivation, or an increase in negative affect (Hagger et al., 2010). Second, it is very difficult to control for the amount of self-regulatory effort exerted during the initial task further making it difficult to pinpoint what is causing ego-depletion. Third, despite the wide consensus of the roles emotion and mood play while persisting, measures of mood and stress via questionnaires or physiological recordings are rarely included.

If persistence does rely on an ability similar to what is suggested, it should be predicted by other abilities such as working memory capacity (WMC), which contributes to goal maintenance, emotion regulation, and controlled attention (discussed below). Whether WMC predicts persistence capacity has never been explored, and in fact, only a few studies have used any individual differences approach at all. Furthermore, a few of the studies that included individual differences suggest that persistence might rely on more than these types of abilities and also be influenced by personality-related variables. For example, those who believe will

power does not have a limited capacity experience less ego-depletion and procrastinate less (Job, Dweck, & Walton, 2010). Explanatory style is a personality variable that might be even more closely related to persistence. It is the way people typically attribute causes to outcomes, especially negative ones. Because these persistence tasks involve inevitable failure, how individuals interpret the cause of that failure (i.e., their explanatory style) seems to be very relevant.

Persistence should be explored while considering both cognitive and personality variables. Even though there is reason to expect both to independently contribute to how long individuals persist, they might also interact, where the degree cognition influences persistence depends on aspects of personality such as how someone typically interprets why he or she fails at some tasks. Even more so, the claims provided by these studies require an individual differences approach. They can only be confirmed by comparing performances across various measures. For example, if persistence capacity relies on particular abilities, then those who outperform others on measures of those abilities should also persist longer than others. However, these types of studies have not yet been performed.

Individual Differences Variables in the Current Study

Working Memory Capacity

The cognitive individual differences variable used in this study was WMC. WMC includes short-term memory retention plus the active manipulation of that information (e.g., controlled attention; Engle et al., 1999). The goal-directed attentional processing allows for focus towards relevant information and away from interfering information. During a working memory span task, a very effective demonstration of these processes, participants are required to maintain items (e.g., words, digits) while performing some simultaneous processes (e.g., arithmetic,

judging sentences on their truthfulness). The executive attention demands of these tasks are similar to those imposed by other complex tasks such as arithmetic, reasoning, and language comprehension (Conway, Kane, & Engle, 2003).

WMC is closely related to goal maintenance and executive control ability. For example, Kane, Bleckley, Conway, and Engle (2001) measured WMC with the operation-word span task where participants attempted to solve simple math problems while simultaneously remembering a list of unrelated words. Next, participants performed a prosaccade task and an antisaccade task. During the prosaccade task, a salient visual cue appeared that was quickly followed by an item requiring identification that then quickly disappeared. High- and low-WMC participants did not differ here. However, during the antisaccade task, the to-be-identified target appeared on the opposite side of the screen from where the cue was presented. Here, high-WMC individuals significantly outperformed low-WMC individuals by being better able to maintain the goal of avoiding the distractor and directing focus toward the cue indicating the role of WMC in executive control.

If persistence is related to self-regulatory processes, then working memory span tasks should be good predictors of persistence capacity. There is good reason to expect this association. For example, as past literature suggests (e.g., strength model of self-control), WM may directly influence persistence similar to WM's role in goal maintenance and emotion regulation (Gray, Braver, & Raichle, 2002). Alternatively, self-regulatory processes may not be actively recruited while persisting, and WM may instead play an indirect role. Because WMC correlates with intelligence and similar measures, those with superior self-regulatory capacities (i.e., high WMCs) may simply enjoy solving puzzles. They are also more accustomed to solving problems and so will continue to persist because they believe they will eventually reach a

solution. Those with inferior self-regulatory capacities (i.e., low WMCs) may be less accustomed to solving problems and perhaps even dread them. If they do not reach a solution very quickly, they understand that they are not likely to reach one at all. Although the exact role WM plays during persistence is not a main goal of this study, it will be briefly considered in the Discussion.

Explanatory Style

The personality variable used in this study was explanatory style. When presented with an event that has a positive or negative outcome, we often produce a causal inference, and what we attribute to the cause of that outcome tends to be consistent with our conception of the world and ourselves (Feiring, Taska, & Chen, 2002). These attributions, or explanatory styles, lead to very different behaviors, and those who adopt optimistic (i.e., positive) explanatory styles tend to be more successful than those who adopt pessimistic (i.e., negative) explanatory styles.

Optimistic explanatory styles have been associated with greater success among sales agents (Seligman & Schulman, 1986), college freshmen (Peterson & Barrett, 1987), and grade school students (Nolen-Hoeksema, Girgus, & Seligman, 1986). Those with pessimistic explanatory styles are more prone to depression, learned helplessness (Metalsky, Abramson, Seligman, Semmel, & Peterson, 1982), and poor physical health (Peterson, Seligman, & Vaillant, 1988).

Abramson, Metalsky, & Alloy (1989) originated this theory while exploring depression and learned helplessness. While experiencing uncontrollable aversive events, if individuals view these events as caused by something about the person, as opposed to the external environment, a loss of self-esteem tends to occur. If the aversive events are interpreted as caused by stable factors instead of temporary ones, then depressive symptoms are likely to be long-lasting. Finally, if the causes of these negative events are extended to several aspects of one's life (social, professional, etc.), then the depression is expected to be pervasive. Abramson identified these

three components as locus, stability, and globality (also referred to as personal, permanent, and pervasive).

Explanatory style is also involved in the coping mechanisms individuals use in the presence of positive and negative outcomes. For example, optimistic individuals often recruit approach coping strategies aimed to manage stressors. On the other hand, pessimistic individuals recruit avoidance coping strategies aimed to avoid or ignore the situation at hand (Solberg Nes & Segerstrom, 2006). Explanatory style particularly focuses on the attributions that individuals assume which are then used in these strategies.

The failures associated with pessimistic interpretations are likely driven by the lack of persistence during tasks that are difficult and frustrating. In the presence of these aversive events, those with pessimistic explanatory styles are likely motivated to avoid and withdraw from the task and choose to quit as soon as they are able to justify it. This is likely facilitated by the increase in negative affect they experience. Those with optimistic explanatory styles, on the other hand, aim to manage their stressors and approach the problem. They focus on completing the task as a solution to the difficulty and frustration.

WMC X Explanatory Style Interaction

The unique feature of this study is examining a potential interaction between these cognitive and personality variables in predicting persistence. It is possible that WMC and explanatory independently predict persistence. Those with high WMCs might persist longer regardless of their explanatory styles, and those with optimistic explanatory styles might persist longer regardless of their WMCs. However, it might also be the case that the degree to which WMC predicts persistence depends on explanatory style. WMC could provide a buffer for those with pessimistic explanatory styles. These individuals are likely to react much more adversely to

a potential failure and rely on WMC to compensate. Alternatively, WMC might be more strongly associated with persistence among those with optimistic explanatory styles compared to those with pessimistic explanatory styles. Having a pessimistic explanatory style might be so debilitating that a high-WMC provides very little benefit for these individuals, and the benefits of WM while persisting only apply among those with optimistic explanatory styles. This diverges from the strength model perspective, which would predict abilities such as WMC alone to be associated with persistence.

Research Overview

The first goal of this study was to explore how individual differences in WMC and explanatory style interact to predict individual differences in persistence capacity. The main measure of persistence (originated by Glass et al., 1969) was derived from a task using a set of five geometric tracing puzzles shown in Figure 1. This task was modified from past uses (e.g., Vohs et al., 2008; Wallace & Baumeister, 2002) with the purpose of including more measures of persistence. Rather than presenting only one puzzle that is unsolvable, five puzzles of seemingly increasing difficulty were presented, one of which was unsolvable (Puzzle 4). Experimental sessions were also video recorded to observe the multitude of behaviors during the task.

Figure 1. Tracing task. Time spent on Puzzle 4 served as our main measure of persistence.

The second goal was to explore how this interaction predicts the mood and stress levels participants experience at the time they give up. We included physiological measures, heart rate (HR) and galvanic skin response (GSR), at multiple times. Electrodermal activity increases when individuals experience negative emotions (Levenson, Ekman, & Friesen, 1990) and has been suggested to be closely linked with personality and cognitive styles (Notarius & Levenson, 1979). Heart rate increases when participants are exposed to stressors such as mental arithmetic, mirror tracing, or being told they will give a speech (Turner, Sherwood, & Light, 1990).

Third, with the use of multiple puzzles (both solvable and unsolvable), we were able to compare performances across them, especially performance on the final puzzle, which was solvable and followed failure on the fourth and unsolvable puzzle. We also included a measure of mood at the end of the task. Not all individuals are susceptible to deficits following failure (e.g., learned helplessness). In his early experiments, Seligman (2006) observed that one-third of his humans never even became helpless when exposed to such a paradigm. It was later discovered that those with optimistic explanatory styles are much less likely to experience learned helplessness in the laboratory (Metalsky et al., 1982). This study will test if this remains true during this laboratory tracing task.

We expected WMC (measured with the reading span and spatial span tests) and explanatory style (assessed by the short form of the Expanded Attributional Style Questionnaire; EASQ-short) to interact such that the degree to which WMC is associated with persistence depends on explanatory style. We also explored how this interaction predicts emotional reactivity as measured by HR and GSR at the time they quit and how individuals recover from failure as measured by performance on the final solvable puzzle and mood at the end of the task.

CHAPTER II

Method

Participants

Ninety-eight participants were recruited from the Psychology department's human subject pool at the University of Colorado Boulder and received partial course credit for their participation. As will be discussed in the Results, a few participants were dropped from analysis leaving 94 total participants in the sample.

Persistence Task

In the past, the use of unsolvable tracing puzzles as a measure of persistence has typically consisted of presenting only one puzzle and quantifying persistence as the time spent attempting that unsolvable puzzle measured with a stopwatch (e.g., Vohs et al., 2008). Because the main goal of this study was to explore which individuals persist more than others, what individuals experience around the time of persistence failure, and how they recover from failure, our persistence task required a much more complex use of the tracing puzzles.

Participants sat at a desk that had a small stand on top of it containing five puzzles (8.5 inches x 11 inches each). The stand allowed participants to flip through the puzzles easily, and each puzzle was placed in a clear plastic sheet so that they could use dry erase markers and an eraser. After HR and GSR hookup (described below), the experimenter read the instructions to the participant. They were told "performance on this task is predictive of future life success due to its links with higher order cognitive abilities" (Vohs et al., 2008). They were instructed to trace each geometric figure completely without lifting the marker from the page and without retracing any lines they already drew. The experimenter demonstrated an example and probed for questions. They were allowed to attempt each puzzle as many times as they wanted, but if they

decided to skip a puzzle, they were not allowed to return to it later. They were told to perform the task until they solved all the puzzles or decided to quit and to inform the experimenter they had finished by ringing a call bell that was on the desk.

The five puzzles were arranged in a way where the first two puzzles looked very easy and the last three looked more difficult. Most important was that Puzzle 4 (unsolvable) did not appear to be the most difficult. To verify this we had an independent sample of undergraduate students from the same subject pool ($n = 20$) rate how difficult the puzzles seemed before attempting them. The first two were rated similarly easy (Puzzle 1: $M = 1.9$, $SD = 1.07$; Puzzle 2: $M = 2.1$, $SD = 1.10$) out of 10 for how difficult they seemed prior to attempting them, $t(19) = .51$, $p = .62$. Puzzle 3 ($M = 5.6$, $SD = 1.10$), Puzzle 4 ($M = 4.7$, $SD = 1.59$), and Puzzle 5 ($M = 6.1$, $SD = 1.52$) were all rated as seeming more difficult than Puzzle 1 and Puzzle 2, $ps < .001$. Finally, Puzzle 4, the unsolvable one, was not rated as seeming more difficult than Puzzles 3 and 5. In fact, it was rated as seeming less difficult, $ps < .001$.

Unbeknownst to the participants, Puzzle 4 was mathematically unsolvable and time spent on this puzzle served as our main measure of persistence. With these puzzles varying in difficulty and solvability, we were able to compare time spent on easy and solvable puzzles to time spent on an unsolvable puzzle. We were also able to examine how long participants performed and whether they solved a seemingly difficult puzzle (puzzle 5) after quitting the unsolvable puzzle, which was rated as seeming significantly more difficult than the unsolvable puzzle.

All sessions were video recorded with a camera aimed down at the participant's work. Using video editing software (OrgSoft Video Editor for Mac), a trained observer coded how long participants spent performing each puzzle and whether they solved each puzzle. The moment a participant flipped to a new puzzle was the start time on that puzzle and the end time of the

previous puzzle. Only one participant took any break during the task, and he was removed from analyses (mentioned in the Results).

WMC

The WMC measures were programmed using PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993) and were presented on an iMac computer. Total items recalled in the correct serial position were summed for the Reading Span Test and Spatial Span Test and then summed together to produce a measure of WMC for each participant.¹

Reading span. The Reading Span Test (Daneman & Carpenter, 1980) required participants to read sentences out loud and verify the truthfulness of those sentences (e.g., “Liquid is sharp and prickly.”). After verifying each sentence, participants were presented with a single word that they were instructed to remember. At the end of each block (12 blocks distributed evenly with two, three, four, or five trials), participants recalled to the experimenter the words in order they were instructed to remember.

Spatial span. The Spatial Span Test (Shah & Miyake, 1996) presented a capital letter (F, P, or R) that was rotated and occasionally mirrored. Participants were required to mentally rotate the image so that they could respond with either “normal” or “mirror-imaged.” After each judgment, participants were presented with a single arrow on the screen and instructed to remember the direction the arrow was pointing. At the end of each block (12 blocks distributed evenly with two, three, four, or five trials), participants recalled on an answer grid the directions of the arrows in order.

Explanatory Style

Participants completed the EAS-short (Whitley, 1991). They were presented with 12 hypothetical negative events (e.g., “You experience a major personal injury”) each of which they

produced a hypothetical cause for that event. They then rated on a scale from one to seven how much the cause of the personal injury was due to them or other circumstances (locus), if that cause would also be present in the future when experiencing a personal injury (stability), and if that cause is something that just influences personal injuries or other areas of their lives (globality). Each of the three component scores were averaged across the twelve negative events and then summed to create a single aggregate score for each participant. Higher scores indicated a more optimistic explanatory style. For example, a score of 21 indicates the most optimistic explanatory style.²

Physiological Recordings

HR and GSR were recorded with the Psylab Stand Alone Monitor. Heart rate was recorded using disposable electrodes placed on the collar bones. GSR was recorded with disposable electrodes placed on the first two distal phalanges of the non-dominant hand. Data were collected with a sampling rate of 40 Hz. Data for each participant include 30-s averages at baseline, beginning, middle, and end of the unsolvable puzzle, and the end of the entire tracing task.

Mood

Participants responded 0 (not at all) to 4 (extremely) to 37 items on the Profile of Mood State (POMS), which was presented before the tracing task (after the instructions) and after the tracing task. Both positive and negative items were summed to create measures of positive and negative mood. Negative mood was subtracted from positive mood and then baseline mood was subtracted from final mood to produce a measure of change in mood. Higher numbers indicate a change in the positive direction.

Covariates

Vocabulary. Participants received a 37-item vocabulary test. They were instructed to choose one of five options that had the same meaning as the target item (e.g., Jovial). Vocabulary correlates well with general intelligence and allows us to explore the relationship between working memory and persistence above other intelligence-related measures.

Enjoyment questionnaire. Participants were asked how often they perform, how much they value, and how much they enjoy a number of activities, one being solving puzzles. The purpose of this item was to explore the influence of working memory above the positive relationship participants have with solving puzzles which is likely to correlate with working memory. These three items were summed for each participant.

Procedure

The experiment was separated into two sessions taking place 3 to 14 days apart so as to not reveal the purpose of the experiment during the persistence task and also so that the task did not influence performance on the WMC measures and responses to the questionnaires. During session 1 (60 min), the experimenter applied the HR and GSR electrodes and participants completed a measure of mood, the tracing task, and a second measure of mood. During session 2 (60 min), participants completed the Reading Span, Spatial Span, and questionnaires.

CHAPTER III

Results

Participants

Although the original sample consisted of 98 participants, a careful screening of the data led to the removal of four subjects from analyses for the following reasons. One participant took an extraordinary long break and put his head down during Puzzle 4 of the persistence task (18 min) and three participants did not respond appropriately to the free response items of the questionnaires (e.g., “because” as a reason for a personal injury). Thus, the total sample consisted of 94 participants.

In addition, some participants had to be dropped from some of the analyses reported below. We did not have physiological data for those whose session ended before they quit the unsolvable puzzle ($n = 1$) and data for performance on Puzzle 5 and mood after the task for those whose session ended during Puzzle 5 ($n = 2$). We are also missing data for HR ($n = 5$) and GSR ($n = 4$) for participants who the experimenter was unable to find a clean recording or when the recording malfunctioned during the session.

Overall Solution Times

Descriptive statistics for time spent performing this task are in Table 1. Participants spent 19.68 min ($SD = 9.30$) on average performing the entire tracing task (range: 2.52 min to 44.68 min). They performed the first easy and solvable puzzle for .92 min ($SD = .85$), the second easy and solvable puzzle for 2.30 min ($SD = 1.80$), the third and moderately difficult puzzle for 2.16 min ($SD = 1.68$), the fourth and unsolvable puzzle for 9.70 min ($SD = 7.11$), and the fifth and moderately difficult puzzle for 4.60 min ($SD = 4.33$). All participants solved the first three puzzles, and 59% solved Puzzle 5.

Correlations between the variables are in Table 2. Overall, there were some relationships with time spent on the puzzles but not with persistence. WMC and explanatory style did not correlate with time spent on Puzzle 1 but did marginally predict how quick participants solved Puzzle 2. Those with high WMCs, $r(92) = -.18, p = .08$, or optimistic explanatory styles, $r(92) = -.20, p = .06$, solved this puzzle faster. Puzzle 2 required adopting a new technique not seen in the practice puzzle demonstrated by the experimenter or in Puzzle 1. This technique was also needed to solve Puzzle 3, which is likely why WMC and explanatory style did not predict how quickly participants solved this puzzle, $r(92) = .05, p = .66$ and $r(92) = .04, p = .71$, respectively. After discovering how to solve Puzzle 2, participants were able to simply apply that technique to Puzzle 3. WMC and explanatory style also did not correlate with time spent on the unsolvable puzzle (Puzzle 4³), $r(92) = .07, p = .52$ and $r(92) = .01, p = .91$, or Puzzle 5, $r(92) = -.02, p = .82$ and $r(92) = .09, p = .40$.

Individual Differences in Persistence (Puzzle 4)

The first goal of this study was to explore how a cognitive and a personality variable, WMC and explanatory style, interact to predict how long participants persist. Our main measure of persistence was time spent performing the unsolvable puzzle (Puzzle 4) before quitting. In the model predicting time spent on this puzzle, we included WMC, explanatory style, and their interaction. As shown in Figure 2, the degree to which WMC predicted how long participants persisted depended on their explanatory style, $\beta_{\text{int}} = .26, F(1, 90) = 6.74, p = .01, \text{PRE}^4 = .0697$. Specifically, having a high WMC did little for those with pessimistic explanatory styles, $\beta_{\text{WM}} = -.14, F(1, 90) = 1.17, p = .28, \text{PRE} = .0128$. However, a high WMC led to more persistence among those with optimistic explanatory styles, $\beta_{\text{WM}} = .38, F(1, 90) = 5.82, p = .02, \text{PRE} = .0607$.⁵

Figure 2. WMC x explanatory style interaction predicts persistence.

Because it is possible that these results were driven by general intelligence or how much participants enjoyed solving puzzles, we also included these as covariates following the method recommended by Yzerbyt, Muller, and Judd (2004). Although performance on the vocabulary test and how much participants value, enjoy, and how often they perform puzzles both predicted how long participants persisted before giving up, $r(92) = .19, p = .06$, $r(92) = .20, p = .05$, the interaction between WMC and explanatory style remained even after controlling for these two variables, $\beta_{\text{int}} = .27, F(1, 78) = 4.87, p = .03, \text{PRE} = .0588$. WMC predicted persistence even after controlling for other measures of intelligence and how much participants enjoy solving puzzles suggesting WM plays an active role in influencing persistence such as during emotion regulation or goal maintenance.

Importantly, this interaction predicted time spent performing the unsolvable puzzle only. It did not predict time spent performing the first two puzzles (combined), $\beta_{\text{int}} = .06, F(1, 90) = .42, p = .52, \text{PRE} = .0046$, or Puzzle 3, $\beta_{\text{int}} = .12, F(1, 90) = 1.33, p = .25, \text{PRE} = .0146$, indicating this relationship between WMC and explanatory is particular to persistence and not general performance on this task.

Stress While Persisting (Puzzle 4)

The second goal of this study was to examine the stress participants experience during this persistence task, especially at the moment they decide to quit the unsolvable puzzle. To examine this, we included measures of HR and GSR. Change in HR and GSR was calculated for each participant by subtracting the 30 s of baseline (i.e., rest before the entire task began) from the mean HR and GSR of the first 30 s, middle 30 s, and final 30 s of performing the unsolvable puzzle. Also, because the time spent performing the unsolvable puzzle is likely to influence HR and GSR, we controlled for time in the analyses that follow.

As illustrated in Figure 3a, similar to how WMC and explanatory style interacted to predict persistence, the degree to which WMC predicted HR at the time participants quit depended on their explanatory style, although this interaction was only marginally significant, $\beta_{\text{int}} = -.22$, $F(1, 80) = 3.37$, $p = .07$, $\text{PRE} = .0404$. Those with high WMCs and optimistic explanatory styles had HRs similar to when they rested before the task began, $\beta_{\text{WM}} = -.29$, $F(1, 80) = 2.33$, $p = .13$, $\text{PRE} = .0283$. Those who had pessimistic explanatory styles, regardless of their WMCs, had faster HRs when they quit the unsolvable puzzle than at rest, $\beta_{\text{WM}} = .15$, $F(1, 80) = .87$, $p = .35$, $\text{PRE} = .0108$. When we control for vocabulary and how much participants enjoy puzzles, this interaction becomes slightly stronger, $\beta_{\text{int}} = -.32$, $F(1, 56) = 3.94$, $p = .05$, $\text{PRE} = .0657$ (optimistic explanatory style: $\beta_{\text{WM}} = -.49$, $F(1, 56) = 5.48$, $p = .02$, $\text{PRE} = .0891$; pessimistic explanatory style: $\beta_{\text{WM}} = .14$, $F(1, 56) = .33$, $p = .57$, $\text{PRE} = .0059$). Important to note, this interaction did not come close to significance for HR in the middle, $\beta_{\text{int}} = -.14$, $F(1, 80) = 1.28$, $p = .26$, $\text{PRE} = .0157$, or at the beginning, $\beta_{\text{int}} = -.14$, $F(1, 80) = 1.31$, $p = .26$, $\text{PRE} = .0139$, of the unsolvable puzzle suggesting that this interaction is particular to stress when participants decided to quit.

In contrast, the results are not as clear cut when predicting GSR at the time participants quit with WMC and explanatory style. There was no main effect of WMC, $\beta = -.11$, $F(1, 81) = .73$, $p = .40$, PRE = .0089, or explanatory style, $\beta = -.15$, $F(1, 81) = 1.63$, $p = .21$, PRE = .0197. There was also no significant interaction, $\beta_{\text{int}} = .08$, $F(1, 81) = .48$, $p = .49$, PRE = .0059, as seen in Figure 3b.

Figure 3a. HR at quit.

Figure 3b. GSR at quit.

The physiological data coincide with the behavioral data discussed above. Having both a high WMC and an optimistic explanatory style is required to be less stressed at the time of giving up. Quitting is a much more stressful experience for other participants possibly leading them to quit much sooner. This points to the possibility that WM is heavily involved in emotional regulation while persisting at a frustrating task; however, this would need to be further tested.

Recovery from Failure (Puzzle 5)

The third goal of this study was to explore how participants recovered after quitting. Participants received a fifth solvable puzzle after quitting the unsolvable puzzle, and 59% of them solved it. Whether or not participants correctly solved the final puzzle was analyzed using logistic regression with WMC, explanatory style, and their interaction. There was no main effect of WMC, $\beta_{\log \text{ odds}} = .18$, Wald $\chi^2(3) = .59$, $p = .44$, or explanatory style, $\beta_{\log \text{ odds}} = .22$, Wald $\chi^2(3) = .94$, $p = .33$. Although the expected interaction does not yet significantly predict whether participants solved Puzzle 5, it was in the expected direction, $\beta_{\log \text{ odds}} = .15$, Wald $\chi^2(3) = .50$, $p = .48$, as illustrated in Figure 4. Having a high WMC increased the probability of solving the final puzzle only for those who had optimistic explanatory styles.

Figure 4. Probability of solving Puzzle 5.

Next we examined the change in mood participants experienced. Change in mood was calculated for each participant by subtracting their baseline mood from their mood after the task measured with the POMS. Higher numbers indicate a change in the positive direction. Also, whether they solved it is likely to influence their mood at the end of the task. For this reason, whether they solved it was included in the model predicting change in mood. As shown in Figure 5a and Figure 5b, the three-way interaction was significant, $\beta_{\text{int}} = -.24$, $F(1, 83) = 5.07$, $p = .03$, $\text{PRE} = .0576$. WMC and explanatory style did not significantly interact to predict the change in mood for those who solved Puzzle 5, $\beta_{\text{int}} = -.23$, $F(1, 83) = 1.97$, $p = .16$, $\text{PRE} = .0232$. Overall, they had more positive moods, $\beta = .28$, $F(1, 83) = 7.26$, $p = .008$, $\text{PRE} = .0804$. However, for those who did not solve Puzzle 5, WMC and explanatory style did interact with marginal significance to predict change in mood, $\beta_{\text{int}} = .25$, $F(1, 83) = 3.38$, $p = .06$, $\text{PRE} = .0391$. Despite not having solved Puzzle 5, those with high WMCs and optimistic explanatory styles were able to maintain more positive moods.

Figure 5a. Change in mood for those who did not solve Puzzle 5.

Figure 5b. Change in mood for those who did solve Puzzle 5.

CHAPTER IV

Discussion

This study explored individual differences in persistence (i.e., how long participants perform an unsolvable task before they decide to quit) and is the first to include both cognitive and personality variables in doing so. The cognitive variable we focused on was WMC, measured with the reading span and spatial span tests, and the particular personality variable of interest was explanatory style, which measures the typical causes people attribute to the outcomes of negative events. We expected the interaction between these cognitive and personality variables to predict how long they persisted on a task that was frustrating and ultimately impossible to solve.

The study yielded three important findings. First, as the results suggest, an increase in WMC within our sample only led to more persistence among those who had optimistic explanatory styles. The debilitating effect of having a pessimistic explanatory style (or a low WMC) is apparently so severe that it requires having both an optimistic explanatory style and a high WMC to be among those who have high persistence capacities. Second, these participants who persisted more than most also did so while feeling less stress at the time they quit. Their HRs were similar to when they were resting prior to the task. Third, participants with high WMCs and optimistic explanatory styles recovered much more effectively after failing as indicated by less negative mood at the end of the entire task and being more likely to solve the final solvable puzzle after quitting the unsolvable one (though whether or not they solved the final puzzle has yet to reach significance).

Although the current study shows that cognitive and personality variables interact to support persistence, what is less clear is the exact role WM plays. Although this is not a specific

goal in this study, we can exclude a few possibilities. One reasonable hypothesis is that those with high WMCs perform this tracing task longer because they enjoy solving puzzles in general. However, as noted in the results, even after controlling for how much participants enjoy solving puzzles, how often they practice solving puzzles, and how much they value solving puzzles, the WMC x explanatory style interaction remained. It is also unlikely that the relationship WMC has with general intelligence led to this effect. Those with high general intelligence are likely accustomed to solving puzzles so might think that if they continue to work at it they will eventually solve it, (conversely, those with low intelligence likely think that if they do not solve it right away, they are unlikely to ever solve it), but this also cannot be the case because the main interaction also remained after controlling for another intelligence-related variable, vocabulary. Therefore, the role WM plays during persistence must be much more specific to WM. Given these participants were less stressed and ended with more positive moods, WM might provide emotion regulation required to persist. As frustration and the tendency to quit arise, those with high WMCs are able to resist the temptation to quit. However, this was not directly tested here.

Limitations

There are a few limitations regarding the mood, physiological, cognitive, and personality measures. First, we were unable to measure mood at various times throughout the persistence task. We do not know how frustrated participants felt other than their physiological levels. With how the persistence task is implemented, we felt that continuously probing for mood would distract participants, provide them with rest while they were managing their own stress, and potentially reveal the purpose of the study. Future studies should attempt to measure mood while participants persist in a way that avoids these methodological consequences.

Second, although we included two physiological measures, the results of one were unclear. The GSR electrodes were applied to the fingertips of the non-dominant hand. Even though participants were instructed to keep that hand as motionless as possible, they did occasionally move it during the task. Perhaps this contaminated the recording. There are several other physiological measures we could have included instead that also respond well to stress such as cortisol levels in saliva.

Third, we only included WMC and explanatory style as our cognitive and personality variables. Including several cognitive variables that reflect the executive functioning framework, for instance, can help further explore the role cognition plays in persistence. There are also several other personality variables that seem relevant such as grit, narcissism, and fixed vs. incremental mindset that measure attitudes individuals have about their own abilities and how strongly they intend to achieve their goals. Future studies should include these measures as well as measures of why participants decided to quit and how they felt their performance compared to others. Again, these types of questions would certainly reveal the purpose of the study with how the task is currently implemented, which would influence their responses on the questionnaires that follow.

Implications

Despite these limitations, this study has important methodological, theoretical, and practical implications. Methodologically, we were able to have a much richer examination of persistence than in past studies. Whereas the majority of studies that use this persistence task use only one unsolvable puzzle (e.g., Vohs et al., 2008), we included a combination of solvable and unsolvable puzzles of varying difficulty. We even included a final solvable puzzle that participants performed after they quit the unsolvable puzzle to measure how they react to failure.

To explore whether mood and stress varies among these participants and whether the ability to control impulsive tendencies influences persistence (the majority of this literature suggests these are the main underlying causes of persistence capacity), we included measures of mood and physiological reactivity, which has not been done. Finally, the majority of studies of persistence used a between-subjects design that explores mean differences in time persisting after some intervention. An individual differences perspective allows us to explore the combination of various cognitive and personality variables and whether WMC, for instance, which is strongly associated with impulsivity, truly does predict persistence.

The current research also has theoretical implications. It is clear now that it is important to consider multiple factors working together when examining how long participants persist and why some persist longer than others. Most important from this study is that pure strength or ability (i.e., WMC) does not predict on its own how long participants persist. How we interpret the challenge significantly influences the impact this variable has on our perseverance. This seriously brings into question one of the prominent theories of self-control and persistence: the strength model of self-control (Baumeister et al., 2007). Although variables such as WMC have never been closely explored with persistence, this model would surely predict this ability to be associated with persistence all on its own because of its association with controlling tendencies and impulsivity.

The literature that uses the strength model of self-control includes several tasks, no matter how seemingly different, into the self-control task category. It assumes if performance on one task suffers after performing a previous task, then both must rely on very similar processes. As the current study shows, the underlying processes influencing persistence are not this simple. Therefore, the strength model should be reevaluated to include personality and cognitive

variables or at the least exclude persistence from its consideration. Furthermore, an individual differences approach would reveal if the main underlying processes driving performance across all these different tasks (e.g., go/no-go, suppressing facial expressions) are similar. If they are similar, those who perform one task well should perform all self-control tasks well. However, this has yet to be reported.

The current study also has important practical implications. In our sample, we were able to highlight individuals who are particularly vulnerable during this task and have low persistence capacities. Those with low WMCs and/or pessimistic explanatory styles gave up significantly sooner. Because WM is difficult to improve, it might be more reasonable to consider interventions that focus on individuals with pessimistic explanatory styles. Seligman (2006) provides evidence that an optimistic explanatory style can be learned. However, this is a very slow process. These workshops span up to 18 months. Self-affirmation could provide immediate relief seeing as it has shown to protect individuals from internalizing stereotype threats when those stereotypes become salient (Miyake et al., 2010). Prior to a persistence task, if participants reflect on important aspects of their lives (e.g., interpersonal relationships, their hard work), they might protect themselves from internalizing the threat of a potential failure and persist longer than usual.

Conclusion

Persistence is a much more complicated process than typically considered. Through the use of an individual differences approach, it is clear that it relies on the combination of various cognitive and personality variables. Most important, our beliefs in our own abilities and how we interpret the causes of negative events play a significant role when we decide to quit a task that is frustrating and potentially unsolvable. Models that attempt to explain variation in persistence

(e.g., strength model of self-control) should be reevaluated or exclude this process altogether, and future research should consider its complexity when isolating vulnerable populations for developing interventions.

Footnotes

¹ We also calculated z-score values of the Reading Span Test and Spatial Span Test and then averaged these for each participant. All patterns were identical to those reported in the Results.

² We included other personality measures (Short Grit Scale, Persistence Scale for Children-Modified, Self-Control Scale), but they will not be included in these analyses.

³ We also applied a square root transformation to the time spent performing Puzzle 4 due to its positive skewness. All patterns were identical to those reported in the Results.

⁴ Proportional reduction in error (PRE) is calculated by dividing the sums of squares reduced by the total sums of squares and is identical to partial eta squared.

⁵ Any mention of optimistic/pessimistic explanatory styles are at $\pm 1/1$ SDs of explanatory style.

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Tables

Table 1. Main independent and dependent variables.

Measures	<i>N</i>	<i>M</i>	<i>SD</i>	Min	Max	Skewness	Kurtosis
Main IVs							
WMC							
Reading Span	94	22.77	4.80	13	39	0.52	0.41
Spatial Span	94	30.85	5.63	15	42	-0.26	-0.3
Total	94	53.62	7.89	37	73	0.16	-0.36
Explanatory Style	94	7.32	1.38	4.67	11.08	0.27	-0.35
Covariates							
Vocab	94	21.57	3.58	11	30	-0.38	0.53
Enjoyment							
Questionnaire	94	15.03	6.99	3	30	-0.08	-1.14
Physiological Recordings							
HR (quit - baseline)	88	2.16	6.23	-12	18	0.26	-0.23
GSR (quit - baseline)	89	0.08	1.85	-6.79	6.73	-0.07	2.76
Mood							
Mood1 (before tracing task)	91	-3.47	8.76	-27	18	-0.46	-0.01
Mood2 (after tracing task)	91	-8.66	13.79	-60	15	-1.29	1.61
Time on Each Puzzle							
Puzzle 1 (solvable)	94	0.92	0.85	0.20	5.40	2.88	9.72
Puzzle 2 (solvable)	94	2.30	1.80	0.32	9.27	1.65	2.69
Puzzle 3 (solvable)	94	2.16	1.68	0.48	10.00	2.31	6.47
Puzzle 4 (unsolvable)	94	9.70	7.11	0.47	33.65	1.36	1.70
Puzzle 5 (solvable)	91	4.60	4.33	0.40	24.75	2.15	5.58
Solved	54	3.73	3.64	0.52	24.75	3.68	18.12
Did not solve	37	6.14	4.94	0.40	20.07	1.05	0.27

Table 2. Correlations.

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13
1. WMC	—												
2. Vocab	.18+	—											
3. Enjoyment Quest	.21*	.07	—										
4. Explanatory Style	-.10	-.13	.03	—									
5. HR (at quit)	-.08	.28*	.16	-.06	—								
6. GSR (at quit)	-.12	-.06	.06	-.14	.11	—							
7. Mood1	-.07	-.10	.08	.18+	.10	.06	—						
8. Mood2	.01	.19+	.15	.09	.22	.03	.60*	—					
9. Puzzle 1	-.05	.05	-.13	.07	<.01	-.24*	-.14	-.16	—				
10. Puzzle 2	-.18+	-.02	-.10	-.20*	-.009	.06	-.13	-.05	.18+	—			
11. Puzzle 3	.05	.05	-.05	.04	-.13	<.01	-.11	<.01	.28*	.20*	—		
12. Puzzle 4	.08	.19+	.20*	.01	.08	.07	-.16	-.05	.22*	0.32*	0.19+	—	
13. Puzzle 5	-.01	-.07	.15	.09	.08	-.20+	-.04	-.21*	.11	-.06	<.01	-.12	—

* $p < .05$

+ $p < .10$