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# Characterizing the executive functioning associated with dispositional mindfulness

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**Abstract**

Previous research shows that dispositional mindfulness is related to cognitive aspects. The relationship between executive functions and dispositional mindfulness is poorly studied. The aim of this work is to characterize the executive functioning associated with dispositional mindfulness. Dispositional mindfulness was evaluated in 90 undergraduates through the Mindful Attention Awareness Scale. In addition, inhibition (Stroop task), cognitive flexibility (rule shift cards), processing speed (digit symbol substitution test), planning (zoo map test) and abstract reasoning (similarities test) were used to evaluate executive function. A multiple hierarchical regression analysis was carried out to predict dispositional mindfulness based on performance in the executive function tests and the individual's age and sex. Age and sex accounted for 0.7% of dispositional mindfulness. Inhibition and cognitive flexibility accounted for 10.8% and 6%, respectively, of dispositional mindfulness, while processing speed and abstract reasoning explained 3.5% and 0.8%, respectively. Lastly, planning accounted for 0% of dispositional mindfulness. Individual differences in self-reported dispositional mindfulness may be caused by differences in executive performance. The good management of cognitive flexibility, the ability to inhibit and the ability to process stimuli more quickly play a crucial role in attending to current experience.

**Keywords** Dispositional mindfulness · Executive functions · Inhibition · Cognitive flexibility · Processing speed · Abstract reasoning

## Introduction

Mindfulness has been extensively studied in recent decades, and the number of scientific papers has increased considerably (Brown et al., 2007). Dispositional mindfulness is defined as the capacity for enhanced awareness and attention to the present moment and experiences (Brown & Ryan, 2003). Mindfulness reflects the innate capacity to pay full attention to our current experience (Segal, 2010).

In general, there have been previous investigations that have provided evidence about the relationship between mindfulness and both emotional and cognitive factors. Previous research has shown that mindfulness is strongly related to emotional variables. In fact, greater dispositional mindfulness has been positively associated with regulatory emotional self-efficacy (Jin et al., 2020), self-regulation (Maltais et al., 2019), life satisfaction (LeBlanc et al., 2019) subjective well-being and life satisfaction and mental health (Brown & Ryan, 2003; Calvo et al., 2020; Baroni et al., 2018). In addition, greater dispositional mindfulness has been negatively associated with psychological distress (Short & Mazmanian, 2013; Chen et al., 2018), anxiety and depression (Barajas & Garra, 2014).

While many works have dealt with the emotional aspects, there are fewer works that have been dedicated to cognitive factors. This fact is surprising since cognitive concepts such as attention and mindfulness are closely related (Keith et al., 2017). Dispositional mindfulness has been related to enhanced sustained attention (Galla et al., 2012), and memory (Rosenstreich & Ruderman, 2016).

It has been suggested that dispositional mindfulness could also require other higher-order cognitive functions that facilitate mindful awareness of the present moment (Lee & Chao, 2012; Riggs et al., 2015). An important set of higher-order cognitive factors are executive functions, which can be defined as a heterogeneous group of processes and abilities that allow for the self-regulation of thought and human goal-directed behavior

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(Diamond, 2013). Among them we can find planning, organization, cognitive flexibility, motivational control, abstract reasoning, updating, use of feedback for behavioral modification, monitoring, and inhibiting automatic responses (Diamond, 2013; Miyake et al., 2000). The aspect that is common to all these functions is that they are linked to the prefrontal cortex (Diamond, 2013). However, the nature of the relationship between dispositional mindfulness and executive functioning is an important unresolved issue that has been addressed by only a small number of studies. Some research has pointed out that dispositional mindfulness is related to better self-reported executive functioning (Lyvers et al., 2014; Riggs et al., 2015; Shin et al., 2016; Short et al., 2016; Wittmann et al., 2014). Other works use objective measurements of executive functioning based on the performance of neuropsychological tasks. On the one hand, it has been found that dispositional mindfulness is related to better performance in tasks requiring the inhibiting of automatic responses (Brown & Ryan, 2003; Keith et al., 2017; Lee & Chao, 2012; Oberle et al., 2012) and increased processing speed (Moore & Malinowski, 2009). On the other hand, training in mindfulness has been shown to improve performance in tasks requiring cognitive flexibility, inhibition of automatic responses (Heeren et al., 2009), and processing speed (Zylowska et al., 2008). There are few investigations that relate dispositional mindfulness to planning and abstract reasoning. Several works show that intervention through mindfulness training does not improve performance in planning tasks (Alfonso et al., 2011), but slightly improves abstract reasoning (Gard et al., 2014; So & Orme-Johnson, 2001; Wen et al., 2013).

However, the investigations carried out to date have some problems. On the one hand, it has been pointed out that self-reports of executive functioning do not correlate strongly with real neurocognitive abilities (Buchanan, 2016). On the other hand, when objective evaluations are used, ecological validity is not considered. In fact, most research uses tasks without ecological validity, which is a particularly serious problem in the assessment of executive performance (Molina et al., 2007). Finally, in each particular piece of research only certain executive functions are evaluated, so that it is difficult to obtain conclusions about the relationship of executive functions to each other in the prediction of dispositional mindfulness. Therefore, the objective of this work is to characterize the executive functioning associated with dispositional mindfulness, overcoming the aforementioned limitations.

## Method

### Participants

The participants were 90 university students (55 females) recruited from undergraduate courses by incidental non-random sampling. We did not perform priori statistical power analysis as these methods may be over-estimated by publication bias (Francis, Tanzman, & Matthews, 2014; Van Aert, Wicherts, & Van Assen 2019). Instead, we perform sensitivity power analysis to determine what minimum effect size we can detect with a power of 0.80 (all calculations were performed with the G * Power 3.1 software (Faul, Erdfelder, Buchner, & Lang, 2009)). The analysis showed that with 90 participants we can detect low to moderate effect size in (Gignac & Szodorai, 2016).Their mean age was 22.94 years (*SD* 1.66 years), and they all identified themselves as Caucasian. The objective of the research was succinctly communicated to all the participants to avoid demand effects (relate cognitive performance and personality), and they were not financially compensated for their participation. They all had normal or corrected-to-normal vision and declared that they did not suffer from any medical or psychological problems and had not abuse alcohol or used psychoactive drugs in the 12 months prior to their participation. The participants signed an informed consent form approved by the ethical committee in accordance with the Helsinki statement.

### Procedure

The participants first completed the self-report forms individually and with no time limit. The researcher placed special emphasis on the importance of responding honestly and explained that there were no correct or incorrect answers. The evaluation of executive function was performed for each participant individually by an expert neuropsychologist in a private and quiet room. The participants were able to take a break during the evaluation session, but none of them did so.

### Measures

#### Dispositional Mindfulness

We assessed *dispositional mindfulness* with the Mindful Attention Awareness Scale (MAAS) (Brown & Ryan, 2003; Soler Ribaudi et al., 2012) which is a 15-item and single-factor self-report. This scale exclusively assesses the individual's ability to be aware and conscious of day-to-day life experiences (Soler Ribaudi et al., 2012). This instrument has good psychometric properties (the Cronbach's alpha coefficient is 0.89 and there is good test–retest reliability) and can be used independently of previous experience in meditation. Item responses are rated on a 6-point Likert scale rating, from 1 (almost always) to 6 (almost never), and the range of scores is from 15 to 90. High scores indicate greater characteristics of dispositional mindfulness.

### Executive Functions

In general, there is agreement in differentiating four groups of executive functions (Diamond, 2013): working memory, inhibition, cognitive flexibility and higher-level executive functions. Since working memory has been widely studied in the previous literature, we decided to focus on the rest of the variables. Specifically, we had a special interest in higher-level executive functions (reasoning and planning) which are practically absent in previous research. In addition, we decided to evaluate processing speed since previous research has only been linked to mindfulness training. The tasks selected to evaluate the different executive functions have been selected based on the ecological validity, the application time, and the availability of our research group.

*Inhibition* was evaluated using the Stroop task (Golden, 2007; Stroop, 1935) (Cronbach's value = 0.60). The task consists of three sheets. The first is called "Word Reading" (W), and the participant looks at the sheet on which there are 100 random examples of color words ("red", "green", and "blue") printed in black (e.g., the word "red" printed in black). The participant is asked to read as many words as possible in 45 s. The number of correct words is counted during this period. The second test is called "Color Reading" (C). Here the participant looks at the second sheet where there are 100 random examples of a string of Xs printed in one of three colors (red, green, and blue) (e.g., XXXX printed in red). The participant is asked to name as many colors of the strings as possible in 45 s. The number of correct words is counted during this period. The third test is called "Colors–Words" (CW). The participant looks at the third sheet on which there are 100 random examples of a color word printed in a different color (e.g., BLUE printed in red). The participant is asked to name the colors of the ink in which the word is printed (ignoring the meaning of the word), naming the color for as many words as possible in 45 s. The number of correct answers is counted during this period. Responding to the color of the ink in which a word is printed (inhibiting the reading of the meaning) is a controlled cognitive process. This incongruence effect is usually referred to as Stroop interference (MacLeod, 2005).

The fig. CW" = (C*W) / (C + W) is then calculated for each participant. CW" is an estimate of the score that the participant should have obtained in the CW condition. Subsequently, the interference score is calculated as CW – CW"; this is the difference between the score that the participant actually obtained (CW) minus the estimate of what he or she should have obtained (CW"). The interference score is an indicator of inhibitory control. If the score is positive, the individual has adequately inhibited the automatic response (reading the meaning of the word), while if it is negative this indicates that the individual has not adequately inhibited the automatic response.

*Cognitive flexibility* was evaluated with rule shift cards from the Behavioral Assessment of the Dysexecutive Syndrome (BADS) battery (Wilson et al., 1996) (Cronbach's value = 0.78), which is a measure with ecological validity. During the task, 21 red and black poker cards are shown to the participant. In the first part, the participant is asked to say "Yes" if the poker card is red and to say "No" if the poker card is black. However, in the second part, the participant is asked to say "Yes" if the poker card is the same color as the one shown previosuly, and otherwise to say "No". A score is calculated from the number of failures and the execution time. The higher the score, the better the task is performed.

*Processing speed* was evaluated with the digit symbol substitution test from the Weschler Adult Intelligence Scale-IV (De la Guia et al., 2012) (Cronbach's value = 0.96). At the top of a sheet of paper is a "key" formed from numbers paired with symbols. At the bottom of the sheet of paper appear 90 numbers. The participant is asked to draw, below each number, the corresponding symbol based on the key, for two minutes. The number of symbols correctly matched with numbers is recorded. Higher scores for this variable indicate better performance.

*Planning* was evaluated using the zoo map test from the Behavioral Assessment of the Dysexecutive Syndrome (BADS) battery (Wilson et al., 1996) which is a measure with ecological validity (Cronbach's value = 0.90). In the zoo map test, participants are asked to plan a visit to a few places in a zoo. The participant must follow a series of instructions: start at the entrance, finish at the picnic area, and use some paths only once and other paths as many times as necessary. The task is composed of two tests with a similar objective (to visit six specific places), but the instructions vary. In the first test, participants only receive a list of the places they should visit. However, in the second test the participants receive a list of the places that they must visit in a specific order. A profile score is calculated from the number of errors, the correct answers and the time to complete the task. The higher the profile number, the better the task is performed.

Data analysis First, the presence of missing responses or duplicate data was checked. Moreover, linearity, normality, homoscedasticity and independence of the residuals and absence of collinearity were checked. The Cook's distance in boxplots were used to identify multivariate and univariate outliers, respectively. Based on the results of the assumptions we decided to perform a multiple regression analysis using 10,000 bootstrap samples. In order to control the confounding effect of the variables age and sex, a sequential hierarchical multiple regression was performed to predict dispositional mindfulness. The predictors were included in the following order: age and sex (step 1), inhibition, cognitive flexibility, processing speed, planning and abstract reasoning (step 2). Step-by-step predictors were included to control the change in $R^2$, and whether or not the inclusion of the predictors in the hierarchical regression models were significant was assessed. In addition, the contribution of each of the predictors was quantified based on their beta and semi-partial coefficients.

## Results

No univariate or multivariate outliers were detected (the highest Cook distance value found was 0.0736). Furthermore, no missing responses or duplicate data were found. Regarding the linear relationship between the predictors and the dependent variable, the data showed that this assumption was only verified for the inhibition, cognitive flexibility and processing speed (Table 1). On the one hand, the Shapiro-Wilk test indicated that there was no normality of the residuals ($W$ (90) = .94, $p$ = .001). However, Koenker test indicated that the assumption of homoscedasticity was satisfied ($LH$ = 12.67, $p$ = .080). On the other hand, the Durbin-Watson statistic showed a value of 1.40 which indicates that the assumption of independence of the residuals is verified (Savin & White, 1977). Finally, although our predictors showed a certain significant linear relationship (Table 1), no multicollinearity was observed (lowest value of tolerance was .775)

At step 1, the model is not significant ($F$(2, 87) = 1.31, $p$ = .275). Age and sex are not significant predictors; in fact, these variables accounted for 0.7% of the dispositional mindfulness (Table 2). At step 2, the model is significant, ($F$(7, 82) = 9.31, $p$ = .000). Inhibition, cognitive flexibility, and processing speed are significant predictors (Table 2). All executive functions accounted for 39.5% of the dispositional mindfulness. Observing the beta values and semi-partial, the most relevant variable is inhibition, followed by cognitive flexibility, processing speed, abstract reasoning, and planning. All the predictor variables show a redundancy pattern among them.

**Table 2** Sequential hierarchical regression of neuropsychological variables to predict mindfulness trait

| | Variables | $\beta$ | *Semi-partial* | *Adjusted* $R^2$ |
|---|---|---|---|---|
| Step 1 | Sex | −.041 | −.040 | .007 |
| | Age | .031 | .030 | |
| Step 2 | Inhibition | .366*** | .329 | .395 |
| | Cognitive flexibility | .279* | .246 | |
| | Processing speed | .211* | .188 | |
| | Planning | −.011 | −.011 | |
| | Abstract reasoning | .095 | .092 | |

*$p$ < .05; **$p$ < .01; ***$p$ < .001

## Discussion

The Objective of this Work Is to Characterize the Executive Functioning Associated with Dispositional Mindfulness. The Results Show that, after Controlling for Sex and Age, Good Performance in the Inhibiting Automatic Responses, Cognitive Flexibility and Processing Speed Task Are Related to Higher Scores of Dispositional Mindfulness. In Addition, the Results Indicate that Abstract Reasoning and Planning Are Poorly Related to Dispositional Mindfulness. The Model with all the Variables Included Explains 39.5% of the Variance in Dispositional Mindfulness, which Is a Large Effect Size (Ellis, 2010; Gignac & Szodorai, 2016). *Inhibition* Accounted for 10.8% of the Dispositional Mindfulness, which Is a Medium Effect Size (Ellis, 2010). The Results Indicate that a Good Ability to Inhibit Automatic Responses Is Related to Higher Dispositional Mindfulness Scores. Other Previous Works Confirm this Finding (Brown & Ryan, 2003; Heeren et al., 2009; Keith et al., 2017; Lee & Chao, 2012; Oberle et al., 2012). This Result Has Consistently Been Found, for a Wide Variety of Inhibitory Control Tasks. On the One Hand, Using a "go / no-go" Task, Keith et al. (2017) and Brown and Ryan (2003)

**Table 1** Descriptive statistics and matrix of correlation among study variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Sex (0 = female; 1 = male) | 1 | | | | | | | |
| Age | .02 | 1 | | | | | | |
| Dispositional mindfulness | −.10 | .13 | 1 | | | | | |
| Inhibition | −.10 | .14 | .54*** | 1 | | | | |
| Cognitive flexibility | −.05 | .07 | .49*** | .35** | 1 | | | |
| Processing speed | −.13 | .05 | .42*** | .29** | .38** | 1 | | |
| Planning | −.05 | −.02 | .17 | .22* | .23* | .20 | 1 | |
| Abstract reasoning | .17 | .19 | .11 | .07 | .03 | −.06 | −.04 | 1 |
| *M* or % (*SD*) | 61% females | 22.94 (1.66) | 58.24 (14.63) | 2.29 (9.02) | 2.71 (1.19) | 75.73 (12.82) | 2.46 (0.86) | 15.07 (2.67) |

*$p$ < .05; **$p$ < .01; ***$p$ < .001

Point out that Dispositional Mindfulness Is Related to Better Response Inhibition Performance. In Addition, Using a "Dots" Task, Oberle et al. (2012) Show that Dispositional Mindfulness Is Related to Enhanced Inhibitory Control. Lee and Chao (2012) Find that Participants Who Score Better in a "Location" Task Score High Values for Acting with Awareness, which Is a Measure of Mindfulness. On the Other Hand, Heeren et al. (2009) Point out that Training in Mindfulness Improves Performance in the "Hayling" Task. It Seems that Individual Differences in the Ability to Be Aware and Conscious of Daily Experiences Is Related to the Better Repression of Automated Trends (Galla et al., 2012). In Addition, Works that Use Self-Reported Measures of Executive Functioning Support the Idea that Dispositional Mindfulness Is Strongly Related to Inhibition (Riggs et al., 2015). Roemer and Orsillo (2003) Point out that Mindfulness Is Mostly Related to Intentional Mental Responses Rather than Automatic Ones. In Fact, the Ability to Be Aware of Experiences Requires Inhibitory Control to Control Intrusive and Distracting Thoughts (Smallwood & Schooler, 2006). *Cognitive flexibility* Accounted for 6% of the Dispositional Mindfulness, which Is a Low to Medium Effect Size (Ellis, 2010). The Results Indicate that a Good Cognitive Flexibility Is Related to Higher Dispositional Mindfulness Scores. Several Investigations Support these Results. On the One Hand, Riggs et al. (2015) Find that MAAS Scores Correlate Positively with Self-Reported Cognitive Flexibility. On the Other Hand, Heeren et al. (2009) Find that the Cognitive Flexibility, Measured by Alternating Fluency Tasks, Is Related to Mindfulness Training. Taken Together, the Evidence Shows that Cognitive Flexibility Is Linked to Individual Differences in the Ability to Be Aware and Conscious of Daily Experiences. It Is Precisely Cognitive Flexibility that Allows the Focus of Attention to Be Changed Efficiently between Different Day-to-Day Experiences (Teper et al., 2013).To the Best of our Knowledge, this Is the First Work that Uses a Task with Ecological Validity to Evaluate Cognitive Flexibility (Molina et al., 2007). Basically, Ecological Validity Ensures that the Results Obtained Allow the Prediction of the Functional Capacity of the Participant in their Day-to-Day Life. Moreover, the Data Show a Redundant Relationship between Inhibition and Cognitive Flexibility. To Explain this Finding, it Is Necessary to Recognize that the Two Functions Are Conceptually Related. In Fact, Cognitive Flexibility Requires Attentional Perseverance on One Object to Be Inhibited so that Attention Can Be Refocused on another. Therefore, Cognitive Flexibility Encompasses Inhibitory Processes (Riggs et al., 2015). *Processing speed* Accounted for 3.5% of the Dispositional Mindfulness, which Is a Low Effect Size (Ellis, 2010). The Multiple Regression Indicates that Shorter Execution Time Is Related to Higher Dispositional Mindfulness Scores. Similar Results Have Been Found in the Literature, although the Tasks Used Vary Considerably. On the One Hand, Moore and Malinowski (2009) Point out that High Scores in Dispositional Mindfulness Are Positively Related to Processing Speed in the "d2" Task. On the Other Hand, Zylowska et al. (2008) Point out that Nine Weeks of Training in Mindfulness Improves the Execution Time for a Visual–Spatial Task. It Seems that Processing Stimuli Quickly Allows an Individual to Be Aware of all the Elements in the Present Moment (Teper et al., 2013). *Planning* Accounted for 0% of the Dispositional Mindfulness. To the Best of our Knowledge there Are no Works that Evaluate Dispositional Mindfulness and Planning in Adult Participants, which Is Surprising since Planning Is One of the most Relevant Executive Functions (Diamond, 2013; Lezak et al., 2004). Mindfulness Training Improves Other Executive Functions but Not Planning Ability (Measured by the Zoo Task) (Alfonso et al., 2011), which Is Confirms by our Results. By Contrast, Black et al. (2011) and Wittmann et al. (2014) Show that Dispositional Mindfulness Is Strongly Related to Self-Reported Impulsivity Control and Self-Control, which Could Be Considered as Evidence against our Results. However, it Should Be Noted that the Concepts of Self-Control and Impulsivity Are Not Interchangeable with the Concept of Planning, Understood as an Executive Function (Wittmann et al., 2014). *Abstract reasoning* Accounted for 0.8% of the Dispositional Mindfulness, which Is a Very Low Effect Size (Ellis, 2010).This Finding Coincides with Previous Works: On the One Hand, Gard et al. (2014) Show that Performance in Raven's Progressive Matrices Accounts for 0.8% of the Dispositional Mindfulness (Gard et al., 2014). On the Other Hand, Reina & Kudesia (2020) Pointed out that Dispositional Mindfulness Is Weakly Related to Raven's Advanced Progressive Matrices. Moreover, Several Works Have Shown that the Practice of Mindfulness Slightly Improves Abstract Reasoning. In Fact, Abstract Reasoning Has a Smaller Effect Size (So & Orme-Johnson, 2001; Wen et al., 2013). Together, these Data Suggest that Abstract Reasoning Is Not Strongly Related to Mindfulness. It Is Important to Note some Limitations of this Research: The Participants Were University Students and their Sampling Was Not Random, so the Ability to Generalize the Results Is Compromised. In Addition, although the Regression Assumes that Executive Functioning Variables Predict Dispositional Mindfulness, we cannot assume Causality because this Study Uses an Observational Cross-Sectional Methodology. On the One Hand, the Theoretical Model of Reina and Kudesia (2020) Must Be Taken into Account, which Emphasizes that "Dispositional" Mindfulness Is Modulated by Situational and Personal Variables. Therefore, it Should Be Considered that Mindfulness Can Vary Substantially within-Person over Time. In Fact, another Limitation Found Is that some Sources of Variation

(Fatigue, Mood, Motivational Aspects) Have Not been controlled and May Be Acting as Strange Confounders. Furthermore, since the Evaluation of Executive Functions and the Completion of the Self-Report Were Carried Out at the Same Time, Common Method Bias May Have Occurred (Podsakoff, Mackenzie, Lee, & Podsakoff, 2003).On the Other Hand, our Sample Size ($n = 90$) Does Not allow us to Exclude the Possibility that some Findings Are False Positives. In Fact, a Much Larger Sample Size ($n = 250$) Would Be Necessary to Ensure that the Relationships Observed in our Analyzes Are Stable (Schönbrodt & Perugini, 2013).Finally, because MAAS Has Been Criticized (Dam, Earleywine, & Borders, 2010), we Include in Supplementary Material a New Regression Analysis Using Only the Items Proposed by Dam, Earleywine, & Borders (2010). In Fact, Comparing the Two Regression we Verify that there Are no Substantial Variations either in $R^2$ or in the Beta Coefficients.Future Research Should Consider these Limitations, Overcome them and Conduct Further Experimental Studies. We Consider that it Could Be Relevant to Evaluate the Relationship between Executive Functioning and Other Mindfulness Dispositional Models Such as the Five Facet Mindfulness Questionnaire. It Would Also Be Interesting to Determine how Executive Functions Relate to Other Cognitive Domains, Such as Memory, in Predicting Mindfulness. In Summary, the Present Study Shows that Individual Differences in Self-Reported Dispositional Mindfulness May Be Caused by Differences in Executive Performance. The Results Presented in the Previous Sections Suggest that Executive Functioning as a Whole Underlies or Is Strongly Associated with Trait Mindfulness in the General Population. Executive Aspects Not directly Associated with Attention Are Linked to the Capacity for Enhanced Mindfulness. The Good Management of Cognitive Flexibility, the Ability to Inhibit, and the Ability to Process Stimuli more Quickly Play a Crucial Role in Attending to Current Experience. Funding the Authors Declare that the Research Was Conducted in Absence of any Funding. Code Availability Not Applicable

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s12144-021-01782-9.

## Declarations

**Ethical Approval** All procedures performed in this study were approved by the institutional research committee.

**Conflicts of Interest/Competing Interests** On behalf of all authors, the corresponding author states that there is no conflict of interest.

**Informed Consent** Informed consent was obtained from all individuals participants included in the study.

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