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Network Analysis Of The Korean GRIT Scale For Unmanned Aeronautical Engineers

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ABSTRACT

Background/Objectives: The intention is to explore the impact of GRIT on unmanned aerial vehicle engineering, while focusing on persistent effort and passion in interdisciplinary learning and operational challenges.

Methods/Statistical analysis: The study uses the Korean 3-Dimensional GRIT Scale to analyze the competencies of UAV engineers, encompassing Effort–Continuity, Passion–Pleasure, and Passion–Meaning. Data analysis includes correlation, factor, and network analysis, evaluating the interactions and importance of competencies. These analyses provide foundational data to enhance the effectiveness of UAV engineering curricula and boost the capabilities of learners.

Findings: This study emphasizes the critical competencies of persistent effort and passion that are necessary for unmanned aerial vehicle (UAV) engineers to effectively address diverse challenges in interdisciplinary areas such as flight, manufacturing, design, programming, hardware systems, and control. Utilizing the newly developed Korean 3-Dimensional GRIT Scale, a deep correlation was discovered between 'Effort–Continuity', 'Passion–Pleasure', and 'Passion–Meaning', providing significant insights to reflect these competencies in educational curricula. The study conducted a survey of 78 UAV engineers using a 5-point Likert scale, and involved applied descriptive statistical analysis, machine learning tools like Pandas, Numpy, and Scipy, and network analysis to examine the correlations among various scale items. The results highlighted the strong interconnectedness of 'Passion–Pleasure' items within the network, underscoring their central role. Network analysis revealed high centrality scores for 'Passion–Pleasure', suggesting the importance of focusing on pleasure and joy in educational program development. This focus is pivotal to enhancing GRIT traits among aeronautical engineers, contributing to their long-term success and satisfaction.

Improvements/Applications: Applications include the development of targeted educational programs that focus on enhancing GRIT traits to boost the persistence, passion, and long-term career success and satisfaction of UAV engineers.

Keywords: GRIT, UAV Engineering, Education, Passion, Interdisciplinary Learning

1. Introduction

Modern high-tech industries are integrating various technologies and disciplines, which is increasing the importance of interdisciplinarity and integration in higher education. In particular, the field of unmanned aerial technology offers a challenging environment that encompasses various areas that include flight, fabrication, design, programming, hardware systems, operation, control, and artificial intelligence [1]. In the industry, it is important to adapt to work based on these various competencies and prepare for new challenges, such as starting a business. In such a challenging environment, it is essential to strengthen competencies such as determination, courage, and passion, to achieve and succeed [2].

The integration of various technologies and disciplines in modern high-tech industries, especially in the field of unmanned aerial technology, requires the enhancement of individual capabilities. Among these capabilities, Duckworth's proposed concept of GRIT plays an important role. GRIT is an acronym for Growth, Resilience, Intrinsic Motivation, and Tenacity, and is considered a key psychological capability for success and

achievement. Duckworth defines GRIT as “the power of passionate persistence that transcends IQ, talent, and circumstance”, symbolizing the commitment and courage required for success and achievement. GRIT also encompasses passion and grit, as well as boldness and undiscouraged persistence, which emphasizes empowerment, which requires twice as much effort as talent [2, 3].

Duckworth has measured GRIT, one of the various competencies required in modern industry, through a 12-item self-report instrument [4, 5]. However, this GRIT scale has been criticized for several problems, one of which is an increase in response error due to an excessive number of reverse questions. Recently, a Korean GRIT scale developed by Soo-Jin Yang and colleagues addressed these issues. The new scale consists of three sub-factors: effort–continuity, passion–pleasure, and passion–meaningfulness, and has been validated for face validity and recruitment validity [6]. The development of this ternary GRIT scale represents an important advance in interpreting and utilizing the role of grit from a new perspective.

Unmanned aircraft technology, or drone technology, became popular in the 2020s, and has become a major field of study in academia. Despite this, there is a lack of research on how to educate drone technicians and improve their educational environment. The current curricula mainly focus on an engineering perspective. This thesis aims to conduct basic research on the educational methods for unmanned aerial technicians, the improvement of their major abilities, and the improvement of their educational environment. In particular, we investigate the correlation between the Korean 3-Dimensional GRIT scale and how passion and persistence can be promoted. For this purpose, we analyzed the passion and persistence of unmanned aerial engineers and examined the correlation between the questions using network analysis.

2. GRIT scale

2.1. *Duckworth’s GRIT Scale*

Psychologists emphasize the component of “GRIT” as an important factor that drives human growth. Duckworth offered an operational definition of GRIT as exploring an individual’s willpower to push beyond their limits. This definition centers on steadfast passion and perseverance toward a long-term goal.

2.1.1. Concepts and measures of GRIT

Duckworth defines GRIT as “the mental ability to push beyond the limits of one’s capabilities” and persevere toward a long-term goal. GRIT refers to sustained focus and effort on a future goal over many years, not just a short period of time, representing a marathon-like interplay of persistence and passion [3, 6]. Duckworth’s GRIT scale consists of 12 questions and measures two key elements of sustained interest and effort.

2.1.2. The problem with Duckworth’s GRIT scales

There are several problems with Duckworth’s GRIT scale. First, it has been criticized that the operational definitions are not sufficiently reflected in the items; in particular, persistence, maintenance, and long-term goals are not sufficiently represented in the items [7]. Second, there is the issue that the overuse of reverse questions leads to response errors and reduced reliability [7, 8]. This is particularly evident in the ‘persistence of interest’ factor, affecting the overall reliability of the scale.

2.2. *The Korean-version GRIT Scale*

Professor Yang’s team modified and supplemented Duckworth’s GRIT scale to develop a Korean ternary GRIT scale. The scale addressed the problems with Duckworth’s scale by adding 10 items to represent the continuity of effort while maintaining the existing effort and passion. Passion was improved to 5 items each, by division into ‘Passion–Pleasure’ and ‘Passion–Meaning’. These adjustments made the structure and content of the scale clearer and more effective.

2.2.1. How to improve the scale

To improve the scale’s factor structure and reverse coding issues, Dr. Yang and her team developed the Korean Ternary GRIT Scale, which retains the original two axes of effort and passion, while revising the persistence of effort to 10 items to reflect it more clearly. Inspired by Duckworth’s scale being primarily focused on the maintenance of interests, we enhanced the scale to measure the direction, intensity, and purposefulness of passion. These changes strengthened the specificity of measuring passion, which was lacking in Duckworth’s scale [9, 10].

While retaining the two existing subfactors of effort and passion, we revamped effort–continuity to 10 items with positive statements. We also refined the passion factor into passion–pleasure and passion–meaningfulness to 5 items each. We reorganized the existing pleasure factor into “Passion–Pleasure” and added a new item related to goals to form the “Passion–Meaning” group. These adjustments improved the structure and content of the scale, making it clearer and more effective [5].

2.2.2. Scales

Table 1 shows the Korean Ternary GRIT Scale, which consists of 20 items. The scale consists of 10 items from Duckworth’s ‘persistence of interest’ factor, reorganized as “Effort–Continuity”. “Effort–Continuity” consists of 10 variables, ranging EC0 to EC9, each of which measures the ability to focus on something continuously for

several months, sustained effort after setting a goal, and perseverance to achieve the goal. The first item is "I can constantly concentrate on something that takes several months to be achieved", and for coding purposes we named this item "Effort–Continuity Zero (EC0)". The subsequent items are named EC1–EC9 respectively. The passion section consisted of 10 items: 5 items for 'Passion–Pleasure' and 5 items for 'Passion–Meaning'. 'Passion–Pleasure' consisted of 5 variables PP0–PP4, measuring passion for the activity, enjoyment of the process, and the degree of immersion in the activity. 'Passion–Meaning' consisted of 5 variables PM0–PM4, measuring the degree of achievement of goals through the activity, and the degree of meaningfulness of the activity. The first item in Passion–Pleasure is "I am deeply lost in this activity", and for coding purposes, we named this item "Passion–Pleasure Zero (PP0)". Subsequent items are named PP1–PP4. The first item of 'Passion–Meaning' is "This activity enables me to achieve my goal", and for coding purposes, this item was named "Passion–Meaning Zero (PM0)", and subsequent items were named PM1–PM4, in order.
Table 1 shows the 20-item questionnaire proposed by Professor Yang's team:

Table 1. Yang Su-Jin Team's GIRT Scale.

Sub-factors	Contents of Items
Effort–Continuity	I can constantly concentrate on something that takes several months to be achieved. (EC0)
	If I start something, I complete it no matter what. (EC1)
	I am diligent. (EC2)
	Once I set a goal, I do something related to it even after time passes. (EC3)
	I maintain my goal or interest even after several months have passed. (EC4)
	I am living my life enthusiastically. (EC5)
	Once I am seized with a thought or plan, I continuously maintain my interest. (EC6)
	I have overcome frustration for important challenges. (EC7)
	I have achieved a goal that took years of effort. (EC8)
	Frustration cannot demotivate me. (EC9)
Passion–Pleasure	I am deeply lost in this activity. (PP0)
	I am fascinated by the charms of this activity. (PP1)
	I enjoy this activity. (PP2)
	I am pleased with the process of this activity. (PP3)
	I feel passionate about this activity. (PP4)
Passion–Meaning	This activity enables me to achieve my goal. (PM0)
	I feel that the process of this activity is meaningful. (PM1)
	I feel the meaning of this activity. (PM2)
	I am achieving my goal while passionately performing this activity. (PM3)
	I have spent time and energy on this activity. (PM4)

To effectively solve various problems faced by unmanned aerial engineers, continuous effort and enthusiasm are essential competencies. This is due to both the interdisciplinary learning contents such as flying, fabrication, design, programming, hardware systems, operation, and control, and the nature of the work, which requires continuous effort and enthusiasm. This competency also includes characteristics that can be expressed in the form of start-ups or ventures. Therefore, it is important to check how the curriculum reflects the required competencies by conducting a network analysis between GRIT factors according to the grade level and curriculum characteristics, as students progress through their studies.
To this end, we conducted a network analysis of GRIT factors among unmanned aerial engineers.

3. Results of data analysis

After surveying 78 unmanned aerial engineers using a 5-point Likert scale, we analyzed the data. To do this, we applied descriptive statistics, and examined the relationships between the various scales. For data analysis, we used Pandas, which is widely used in machine learning, and additionally used libraries, such as Numpy and Scipy. For machine learning, we used Sklearn to analyze the data.

3.1. *Descriptive Statistics Analysis*

Descriptive statistical analysis was conducted on 78 unmanned aerial engineers. The data analysis results for 10 questions of "Effort–Continuity" were as fallow: On a 5-point scale, the means of "Effort–Continuity" of EC0 and EC1 were (3.86 and 4.15), respectively, while the means of EC2–EC9 were (3.23, 3.79, 3.95, 3.77, 4.13, 3.63, 3.47, and 3.44), respectively. The standard deviations for EC0 and EC1 were (0.83 and 0.76), respectively, and EC2–EC9 were (0.94, 0.83, 0.85, 0.77, 0.63, 0.84, 1.03, and 0.97), respectively. For skewness, EC2 was right-skewed, while EC0, EC1, and EC3–EC9 were left-skewed, but all were below the absolute value of 1. For kurtosis, EC1, EC3, and EC5 were sharper than normal, while the others were smoother than normal, but did not exceed the absolute value of 1.

On a 5-point scale, the means of PP0 and PP1 of "Passion–Pleasure" were (3.42 and 3.59), respectively, and of PP2–PP4 were (3.95, 3.77, and 3.83), respectively. The standard deviations for PP0 and PP1 were (0.93 and 0.87), respectively, for PP2–PP4 were all 0. The skewness was right-skewed for PP0 and PP3, and left-skewed for the others, but all were below the absolute value of 1. The kurtosis values were all smoother than normal, but only PP1 was –1.03, and none were above the absolute value of 1.

The descriptive statistics for the five "Passion–Meaning" items showed that on a 5-point scale, the means for PM0 and PM1 were (4.0 and 4.19), respectively, and for PM2–PM4 were (4.12, 3.63, and 3.7), respectively. The standard deviations for PM0 and PM1 were (0.81 and 0.77), respectively, and for PM2–PM4 were (0.76, 0.87, and 0.98). The skewness was right-skewed for PM3 and left-skewed for the rest, but all were below the absolute value of 1. The kurtosis values were all smoother than the normal distribution, but only PM2 had a kurtosis of –1.21, while the rest were above the absolute value of 1.

3.2. *Correlation and reliability analysis*

To identify the important variables related to the GRIT traits of aeronautical engineers, we conducted a correlation analysis of 10 items on "Effort–Continuity", 5 items on "Passion–Pleasure", and 5 items on "Passion–Meaning". Table 2 shows the results of the correlation analysis of the 10 items of "Effort–Continuity", while Table 3 shows the results of the correlation analysis of the 5 items of "Passion–Pleasure", and Table 4 shows the results of the correlation analysis of the 5 items of "Passion–Meaning". All 20 questions, including 10 questions on "Effort–Continuity", 5 questions on "Passion–Pleasure", and 5 questions on "Passion–Meaning", met $p<.05$. In particular, the correlation between the five items of "Passion–Pleasure" was very high, compared to the correlation between the items of "Effort–Continuity" and "Passion–Meaning". The correlation coefficients between items were in the order PP(Passion–Pleasure) > PM (Passion–Meaning) > EC (Effort–Continuity), with the highest correlation between items in PP. The correlation coefficient between PP0 and PP1 was 0.836, between PP2 and PP3 was 0.798, between PP3 and PP4 was 0.793, between PP1 and PP3 was 0.765, and between PP1 and PP4 was 0.762.

Table 2. Correlation of Effort–Continuity.

N = 78

	EC0	EC1	EC2	EC3	EC4	EC5	EC6	EC7	EC8	EC9
EC0										
EC1	0.67*									
EC2	0.37*	0.28*								
EC3	0.58*	0.55*	0.31*							
EC4	0.61*	0.38*	0.29*	0.39*						
EC5	0.35*	0.53*	0.54*	0.45*	0.38*					
EC6	0.5*	0.56*	0.3*	0.4*	0.5*	0.49*				
EC7	0.33*	0.44*	0.36*	0.41*	0.37*	0.43*	0.43*			
EC8	0.35*	0.42*	0.34*	0.3*	0.3*	0.42*	0.36*	0.55*		
EC9	0.35*	0.26*	0.37*	0.39*	0.45*	0.34*	0.31*	0.52*	0.23*	

p < .05 (*)

Table 3. Correlation of Passion–Pleasure.

N = 78

	PP0	PP1	PP2	PP3	PP4
PP0					
PP1	0.84*				
PP2	0.66*	0.76*			
PP3	0.72*	0.76*	0.8*		
PP4	0.68*	0.76*	0.69*	0.79*	

p < .05 (*)

Table 4. Correlation of Passion–Meaning.

N = 78

	PM0	PM1	PM2	PM3	PM4
PM0					
PM1	0.75*				
PM2	0.66*	0.74*			
PM3	0.63*	0.59*	0.58*		
PM4	0.44*	0.49*	0.47*	0.65*	

p < .05 (*)

To understand whether effort continuity and passion meaning are related, we conducted a correlation analysis between the variables "Effort–Continuity" and "Passion–Meaning". As a result, the correlation coefficient between EC4 and PM2 was 0.514, the correlation coefficient between EC8 and PM4 was 0.505, and all others were 0.5. These results show that certain elements of effort–continuity are related to passion–meaningfulness. In particular, the correlation between EC4 (maintaining a goal or interest after many months) and PM2 (feeling the meaning of this activity) indicates the importance of finding meaning in an activity while persisting in effort. The correlation between EC8 (achieving a goal after years of effort) and PM4 (investing time and energy in this activity) suggests that long-term goal achievement and investment in an activity are linked.

These findings suggest when developing educational programs for aeronautical engineers, it is important to emphasize persistence of effort and finding meaning in activities. These attitudes can help aeronautical engineers find meaning and value in the process as they work toward their long-term goals.

To determine whether effort–continuity is related to passion–pleasure, we conducted a correlation analysis between the variables "Effort–Continuity" and "Passion–Pleasure".

EC0 ("I can constantly concentrate on something that takes several months to be achieved") and PP2 ("I enjoy this activity") were correlated at 0.514. This means that individuals with higher levels of focus on long-term goals tend to enjoy the activity more. This suggests that commitment to long-term goals and enjoyment of an activity are linked.

EC3 ("Once I set a goal, I do something related to it even after time passes") and PP0–PP4 (various statements related to Passion–Pleasure) had correlations of (0.501, 0.510, 0.533, 0.549, and 0.528), respectively. This suggests that the ability to persist in a related activity after setting a goal is strongly associated with enjoyment of the activity, and that goal-directed effort can increase the amount of enjoyment felt in an activity.

EC5 ("I am living my life enthusiastically") and PP1–PP4 (various statements related to Passion–Pleasure) were (0.512, 0.547, 0.541, and 0.559), respectively. This indicates that individuals who live their lives with passion tend to have greater enjoyment of certain activity, and suggests that passion in everyday life may be positively related to enjoyment in professional activities.

EC7 ("I have overcome frustration for important challenges") and PP0–PP2 (various statements related to Passion–Pleasure) had correlations of (0.568, 0.533, and 0.552), respectively. This means that the ability to overcome significant challenges is strongly linked to enjoyment of the activity, and suggests that the sense of accomplishment felt in overcoming challenges may contribute to increased enjoyment of the activity.

EC9 ("Frustration cannot demotivate me"), and PP0 and PP1 (various statements related to Passion–Pleasure), were correlated at (0.551 and 0.517), respectively. This suggests that being resilient to setbacks is positively associated with enjoying an activity, and shows that an attitude of persisting in an activity despite setbacks can increase the enjoyment of that activity.

Based on these data, we conducted a reliability analysis by calculating Cronbach's alpha. As a result, the reliability of each variable was very high, with Cronbach's alpha values for the 10-item "Effort–Continuity", 5-item "Passion–Pleasure", and 5-item "Passion–Meaning" scales of (0.87, 0.95 and 0.88), respectively.

4. Network analysis results

To understand which variables play a central role in the network, we conducted a network analysis of the correlations between the 20 questions. Figure 1 shows that 10 of the 20 questions have a high degree centrality. In particular, the "Passion–Pleasure" variables are strongly correlated with each other and play a central role in the network, i.e., the centrality score of PP1 is 0.684, PP2 is 0.632, PP3 is 0.579, PP4 is 0.579, and PP0 is 0.526. In particular, PP1 scored high on all centrality indicators, indicating that it is the most influential variable in the network. This suggests that the "Passion–Pleasure" factor may play an important role in developing and strengthening the grit trait in aeronautical engineers, which means that when developing an education program for unmanned aerial engineers, a focus on the "Passion–Pleasure" factor may be necessary to guide and strengthen the grit trait. The remaining items with high Degree Centrality Scores in "Passion–Meaning" were PM0, PM2, PM3, and PM4 and in "Effort-Continuity", one item EC3. Their Centrality Scores were ordered PM3 > PM0 > PM2 > EC3 > PM4. The metrics were 0.474 for PM3, 0.421 for PM0, 0.421 for PM2, 0.368 for EC3, and 0.368 for PM4.

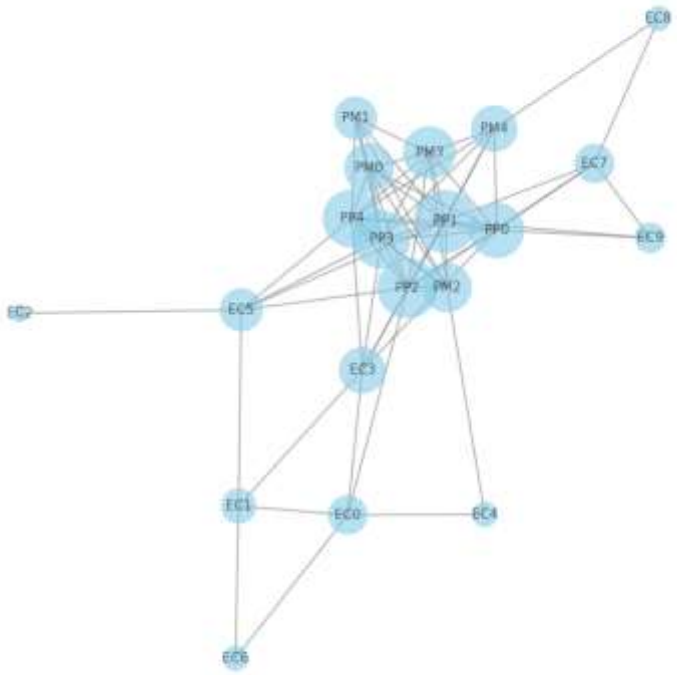

Figure 1. Network analysis based on centrality.

To understand more specifically how the relationships between these variables affect GRIT traits, we conducted a network structure analysis. Table 5 shows the results:

Table 5. Correlation of Effort–Continuity.

Centrality	PP1	PP2	PP3	PP4	PP0	PM3	PM0	PM2	EC3	PM4
Degree Centrality	0.684	0.632	0.579	0.579	0.526	0.474	0.421	0.421	0.368	0.368
Betweenness Centrality	0.148	0.179	0.054	0.054	0.048	0.013	0.005	0.072	0.075	0.064
Closeness Centrality	0.731	0.731	0.679	0.679	0.613	0.594	0.559	0.559	0.576	0.543
Eigenvector Centrality	0.362	0.338	0.34	0.34	0.297	0.302	0.278	0.252	0.205	0.23

The characterization of each question by betweenness centrality shows that only PP2 and PP1 play a significant role in mediating interactions with other elements in the network. PP2 has the highest betweenness centrality of 0.179, while PP1 has 0.148. PP3 and PP4 have lower betweenness centrality, suggesting that they play a lesser role in the network. The betweenness centrality of PP3 and PP4 was 0.054, while the betweenness centrality of PP0 was 0.048.

The item-by-item characterization by closeness centrality showed that PP1 and PP2 had a closeness centrality of 0.731. Both these questions have high closeness centrality. This indicates that they are quickly and efficiently connected to other elements in the network. PP3 and PP4 have a relatively high closeness centrality of 0.679, suggesting that they are easily connected to other nodes in the network. PP0's closeness centrality of 0.613 is somewhat lower, compared to the other PP questions, indicating that it is less efficiently connected to other nodes in the network. The remaining PM3, PM0, PM2, EC3, and PM4 questions have relatively low closeness centrality, indicating that they are less efficient in connecting with other nodes in the network.

The characterization of each question by Eigenvector centrality shows that PP1 has an Eigenvector centrality of 0.362, which means that PP1 has relatively high centrality, and is well connected to important nodes, and therefore, well connected to other influential questions. The Eigenvector centrality of PP2, PP3, and PP4 is around 0.34, suggesting that these questions are also well connected to important nodes. The Eigenvector centrality of PP0 is 0.297, and PP0 has a somewhat lower centrality than the other PP questions, indicating that it has relatively few connections to important nodes. PM3, PM0, PM2, EC3, and PM4 have relatively low Eigenvector centrality, which suggests that they are less well connected to important nodes.

This analysis shows the importance when developing educational programs for aeronautical engineers of emphasizing passion and finding meaning. These attributes can contribute to achieving long-term goals and maintaining sustained effort.

5. Conclusion

This study shows that UAV engineers need to emphasize persistence and passion as key competencies to effectively solve the various problems they face. This is because these competencies are important both for learning in interdisciplinary fields, such as flight, fabrication, design, programming, hardware systems, operation, and control, and for entrepreneurial activities, such as start-ups and ventures.

When analyzed through the newly developed Korean Triadic GRIT Scale, we found a strong correlation between "Effort–Continuity", "Passion–Pleasure" and "Passion–Meaning". This has important implications for reflecting the competencies required in the curriculum. Based on this, we found that a training program to enhance the GRIT traits of aeronautical engineers should be structured as follows:

First, develop a program centered on passion and enjoyment. Develop a program that includes hands-on learning, creative projects, and team-based activities to engage learners in passion and enjoyment. Second, emphasize long-term goal setting and persistence. Include goal-setting workshops, progress checks, and mentoring systems to help learners set long-term goals and stay committed. Third, focus on making activities meaningful. Allow learners to choose their own project topics or participate in projects that solve socially meaningful problems, so that they can find their passion and meaning. Fourth, provide opportunities for feedback and reflection. Regular feedback sessions, journaling, and peer assessment can help learners recognize their growth and make necessary adjustments. Fifth, showcase success stories and role models. Inspire learners by sharing stories and providing role models of professionals who have built successful careers in aeronautical engineering.

Training programs structured in this direction will strengthen the grit traits of aeronautical engineers and contribute to their long-term success and satisfaction, which can contribute to achieving targets and sustaining efforts.

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