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# The Effects of GUI on Users' Creative Performance in Computerized Drawing

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**Abstract**

This paper presents the results of an empirical comparative study investigating how the results of a computerized figural creativity test are affected when the participants use two different versions of the User Interface (UI) on a mouse-operated desktop PC. The results show that participants get slightly higher creativity scores with the interface that has no visual artifacts available and offers more similar user experience to pen and paper, contrary to the more elaborated one. That phenomenon is expected to contribute to the cumulative effect of GUI and input method noticed by previous research. That implies that creative drawing and testing should be carefully introduced into computer-based environments.

**Author Keywords**

Mouse; User Interface; evaluation; comparison; creativity; test; TTCT; figural; drawing

**ACM Classification Keywords**

H.5.2 [User Interfaces]: Evaluation/methodology, Graphical user interfaces (GUI), Input devices and strategies.

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## Introduction

Users' performance issues related to computer input methods, and User Interface design and use are still the core topics in Human-Computer Interaction (HCI) research. But nowadays, more and more people interact with computers also during their creative or artistic endeavors. For example idea-sketching has an important role in the creative process in the early phase of design. This topic has been experimentally studied and nowadays idea-sketching is supported by many computerized tools [1]. Yet, drawing tasks that require a creative approach demand a lot of freedom and therefore are too complex to be predicted by spatio-temporarily restrictive HCI models that are traditionally focused on the accuracy in navigational pointing or steering tasks [2, 3].

Any computer-based solution introduces a few potential areas of problems that relate to application's logic, its implementation in the Graphical User Interface (GUI), and the input method used. Moreover, the evaluation process, used for comparison of tools, can create additional constraints e.g. the ones introduced by the particular method of testing or even formulation of the test tasks.

Previous studies on shape tracing [4–6] show the varying impact the input devices have on the accuracy and time of such interaction. However, this effect has not been found significantly influential in creative drawing tasks [7]. On the other hand, the impact of command selection (which was both the time to select the command and to resume drawing) has been evaluated experimentally using several GUI configurations and it has been found as modality-dependent and significantly affecting the drawing time and errors made [8].

To expand our knowledge about the influence GUIs

have on the user's performance in creative drawing task we decided to perform a comparative study of two versions of the computer-based figural part of the Torrance Tests of Creative Thinking (TTCT) which provides the participant with the drawing situation and additionally offers a standardized measure of the participant's creativity.

## Previous Works

### *The TTCT*

The TTCT has been developed by Ellis Paul Torrance in 1960s and since then its validity has been assessed by longitudinal studies carried out internationally [9]. The test includes two types of subtests:

- *The TTCT-Verbal* consists of forms A and B that include the following activities: Asking Questions, Guessing Causes, Guessing Consequences, Product Improvement, Unusual Uses, and Just Suppose.
- *The TTCT-Figural* also has two equivalent forms (A and B) that include two different sets of stimuli and include with three activities each.

The TTCT-Figural is performed according to the TTCT Directions Manual [10] and includes three activities:

- I. *Picture Construction Activity* - requires the participant to draw a picture in which a closed shape is an integral part.
- II. *Incomplete Figures Activity* - where the participant is provided with 10 different open shapes and is required to draw as many pictures as possible with each shape as an integral part.
- III. *Repeated Figures Activity* - provides 30 sets of paired parallel lines or 36 circles distributed over multiple pages for a participant to make and draw multiple associations to a single stimulus.

In each activity participants have to write the titles of their drawings which are also used for grading purposes.

In this study we used Form B of the figural part of the Torrance Tests of Creative Thinking that includes a set of stimuli usually offered to adult participants, and refer to as *the TTCT*.

#### *Raw Scores and Creativity Index*

The TTCT offers a standardized measure of the participant's creativity. The very elaborated scoring procedure of the TTCT [11] can be taught easily and produces valid and reliable assessments of five principal qualities of user's creative performance:

- *Fluency* - number of relevant responses
- *Originality* - novelty of unusual but relevant responses
- *Abstractness of Titles* - a verbal measure
- *Elaboration* - the number of details used to extend a response
- *Resistance to Premature Closure* - a person's ability to stay open and tolerate gestalt ambiguity.

These elements are individually graded and summarized between all three activities of the TTCT in form of raw scores. These raw scores are later incorporated into a final standardized score: the Creativity Index (CI) representing the users' overall creative performance in relation to the rest of population.

Even though it is not directly supported by the TTCT method, we decided to follow the approach from other studies using the TTCT [7, 12] and also made use of the intermediary raw scores, and grouped them to describe users' performance in each activity of the TTCT separately.

#### *Computerized TTCT*

Ambiguity - defined as the ability to embrace multiple meanings or interpretations - serves as a desirable element of the aesthetic expression especially in creative works. It is considered advantageous because it opens up the possibility of supplementing system's technical constraints with users' interpretations [13]. It is hard to predict to what extent a particular UI feature will constrain or support user's creative performance [14]. Therefore, one of many concerns of UI design is how to address ambiguity that may originate from attributes of given technical solution, its alternative uses, but also from richer understanding of user's attitudes [15]. Four qualities of ambiguity in interactive systems has been identified by previous research [13]: *imprecision* (under or over-interpretation of information leading to doubt), *playfulness* (removing more serious attitudes impeding experimentation), *conceptual appropriation* (encouraging alternative uses of system's functions), and *provocation* (triggering certain reactions of users). Interfaces that introduce imprecision are expected to induce more interpretations than clear and consistent ones. Also, users who expect clarity and consistency are more likely to perceive ambiguity [13]. And because traditional UI design aims for clarity, precision, and efficiency of use, not all kinds of systems are expected to benefit from ambiguity [15]. Moreover, ambiguity can be sometimes considered as a disadvantage to UI design [16]. Because the level of accuracy offered by different kinds of input devices will likely vary [6] and might be different than expected by the user, it partially shifts the responsibility for interpretation of user's actions to the user. And it has been already found that the lack of precision of the computer system may yield negative reactions that lead to users' frustration when facing ambiguity [17].

We can find traces of these issues in a previous attempt of creating a mouse-operated computer-based version of the figural TTCT [18] reporting that this version is not equivalent to the original paper-and-pencil version of the test. A quick analysis of that study setup highlighted two main aspects of the UI used that might have played an important role there.

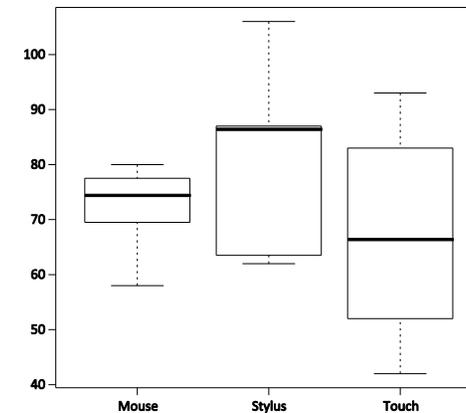
#### *Computerized TTCT - Input method*

One of the major confounding factors that might influence the outcome of any interaction is the computer input method used. The regular pen is a *direct* interaction tool in a sense that the outcome of using a pen is offered in the same place where the interaction takes place. Additionally, the pen offers also absolute mapping between the pen movements and the feedback e.g. a line drawn. Contrary, in case of the computer mouse the fact that the feedback of mouse movements is presented on a display that is spatially separated makes the whole interaction more *indirect* [19]. Additionally, mouse movements can be converted to movements of a screen-cursor with a controller-display gain that allows the user to move the cursor a great distance with only a short mouse movement. While these different characteristics of pen and mouse seem to translate to slightly higher drawing accuracy and slightly shorter task times in case of a computer stylus, the differences between these two input methods are not significant [6]. Still, mouse users can produce less aesthetically appealing drawings what may have some influence on the user's creative process but it is not a factor that is graded in the TTCT. The more recent research on the role of input methods in a computerized version of the TTCT showed that the digitalization of the test (i.e. the transition from pen and paper to stylus and screen) does not influence the

results [20]. The differences introduced by mouse, stylus, and touch (see Figure 1) cannot be neglected but are also reported as not significant [7].

#### *Computerized TTCT - GUI design*

UI design has a profound impact on user's experience and performance. Kwon's computerized version of the TTCT [18] had an elaborated GUI with its artifacts



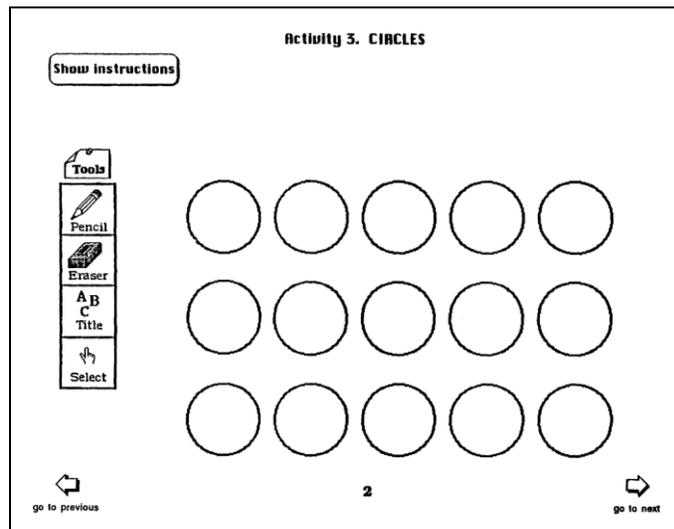
**Figure 1.** Box plot of users' raw scores obtained with the use of mouse, stylus, and touch-input in [7].

being constantly displayed on the screen during the test (see Figure 2). It has also been tested that the GUI offering simple and uniform user experience of the real pen and paper, deliver similar TTCT results to paper-based version of the test [20]. In that case the GUI used offered no visible GUI artifacts and the activities were switched on external keyboard.

### Computerized TTCT – GUI’s functionality

Any implementation of the paper-based TTCT into universal computer software must be a result of many compromises therefore it might not be a perfect solution. The navigation between activities of the test can be presented on the screen in form of buttons or made available with keyboard buttons or even on-screen hand gestures.

Also the basic decision if to implement an eraser’s functionality or not, may have consequences in the UI design and potentially influence the use-generated outcome.



**Figure 2.** Screenshot of Activity 3 of the TTCT used in [18].

First, such a function can be offered by the input device or by the GUI only – e.g. in form of a button. E.g. in case of mouse the right-click could offer the eraser mode while the left-click could be used for drawing.

Capacitive stylus might offer an eraser function if used with its opposite end then the one used for drawing. But it would be hard to implement eraser e.g. for touch-input, without creating some visual metaphor. On the other hand the GUI eraser button could be used with mouse, stylus, and touch input. Additionally, after overcoming the functional fixedness [21] the eraser can also be used as a kind of a brush tool that might influence the outcome of the test. The TTCT method is not explicitly clear about offering the eraser function suggesting using ordinary pencils or crayons.

### Research Question

Taking issues mentioned above into consideration it is hard to say a-priori how particular characteristics of software solution may potentially support or hinder user’s performance in creative drawing task. Therefore, we have decided to experimentally address the following research question: How does the simple and advanced GUI’s design and functionality influence users’ performance in creative drawing task?

### Procedures and Methods

To answer the question about the influence of GUI on the user’s creative performance in the TTCT - two versions of test’s GUI design have been experimentally compared: advanced and simple.

#### *Two Versions of GUI*

In case of computer-based drawing the central feature is the combination of software and hardware creating a tool that allows a user to draw. Therefore, both versions of GUI allowed to create a 5 pixel thick solid-black trace of drawing left by the user after pressing the left button of the mouse. Additionally, the TTCT procedure involves showing the participants different

sets of stimuli within the test's three activities, that they have to respond to by drawing and giving the title to the final outcome. Therefore, each version of the GUI showed the stimuli shapes generated using 5 pixel thick solid-black lines, and displayed on a white background that occupied full area of the screen. To avoid a bias of the differences potentially introduced by different GUI solutions for text entry that would have to be used, and for the sake of consistency with previous studies using that GUI design - regular paper and pen was offered to the participants for writing down the titles of their drawings in both versions of the GUI.

*Simple GUI* (see Figure 3 - top) – the first tested version of the TTCT's GUI has been developed in an attempt of creating a digital equivalent of the paper-based TTCT. The GUI is non-existent and only the test stimulus is presented on the screen - e.g. the activity presented on the Figure 2 showed only the three rows of circles displayed on the screen. The activities of the TTCT were switched with external keyboard. This version of GUI was used in [20] and [7]. Eraser's functionality has not been implemented.

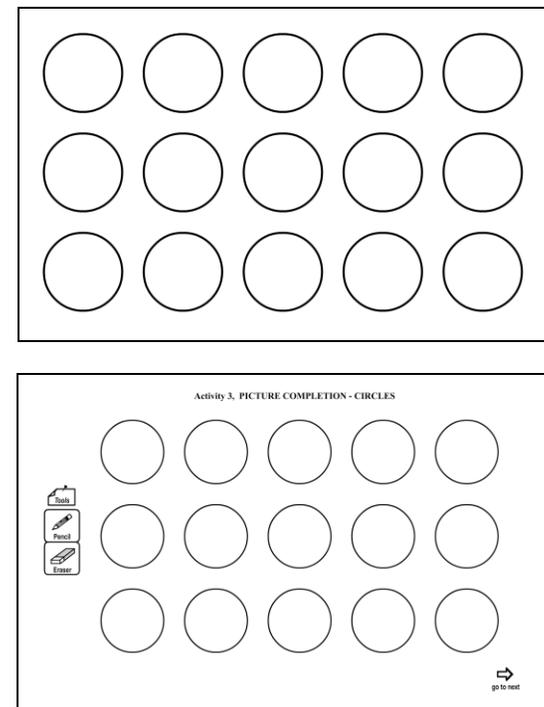
*Advanced GUI* (see Figure 3 - bottom) – this version of the TTCT's GUI has been heavily based on the Kwon's computerized version of the TTCT [18] (see Figure 2). The activities of the TTCT were switched with navigation buttons available in GUI. The eraser's functionality was also available in form of a GUI button.

#### *Experiment Design*

A series of full consecutive creativity tests taken by each user with both versions of the TTCT's GUI would produce biased results. Therefore, a between subject

study was performed where 8 randomly assigned participants used simple GUI, and the other 8 participants used advanced GUI.

The screen snapshots with participant's drawings were collected and analyzed to provide the raw scores and CI scores obtained by the participants solving the TTCT. Additionally, the time the participants spent on active drawing was measured in each activity of the TTCT. The drawing was considered continuous if it was not interrupted for more than 5 seconds.



**Figure 3.** Screenshot of simple (*top*) and advanced GUI (*bottom*) used in this study showing activity 3 of the TTCT.

### *Participants*

16 volunteers (8 females and 8 males) aged between 20 and 32 years old (average of 25 years old) have been recruited among students of Uppsala University. None of them had previous knowledge of the TTCT method.

### *Hardware*

To recreate the hardware and software setup used in the previous study on computerized TTCT [18], the participants used a mouse-operated stationary desktop HP computer (3 GHz Intel Xeon CPU, 3GB RAM), with the Samsung SyncMaster 172x display screen with 1280x1024 pixels resolution, standard keyboard, and DELL Optical USB 5 Button Scroll Mouse.

### *Software*

The computer was running Microsoft Windows 7 64bit with default settings and both versions of the TTCT's GUI that have been used in this study. All the user's actions, system events, computer's screen view and a picture from an external video camera were recorded with TechSmith Morae v.3.2.

### *Test Scenario*

The participants took part in a short introductory session to familiarize them with the interface given, and after that they performed all three activities of the TTCT in original order. The participants used the keyboard (simple GUI) or on-screen navigation buttons (advanced GUI) to switch between the sub-pages of given activity and between activities of the TTCT (after 10 minutes the latest).

## **Results**

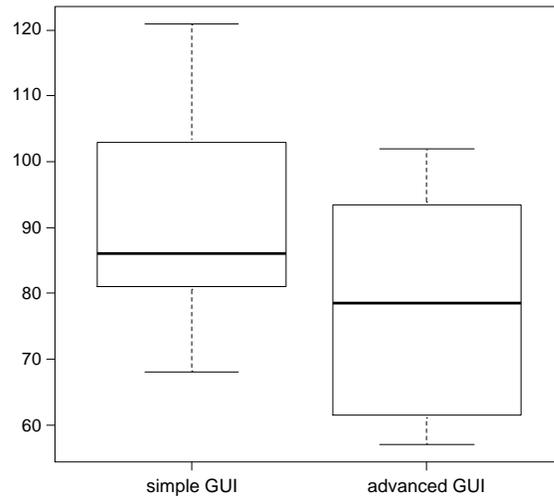
The screen snapshots with the participants' drawings were analyzed by two untrained raters who performed the scoring according to TTCT scoring manual [11]. The resulting raw scores and CI scores have been compared to estimate inter-rater reliability and Pearson's correlation coefficient of 0.89 has been achieved indicating a strong positive correlation between raters. The average scores from both raters have been used later in the analyses.

An ANOVA of the participants' CI scores (see Figure 4) showed that the differences between the results obtained using different versions of the GUI are not significant ( $F_{1,14}=2.2453$ ;  $p=0.1562$ ). Similarly, for the raw scores (see Figure 5;  $F_{1,14}=2.3527$ ;  $p=0.1474$ ).

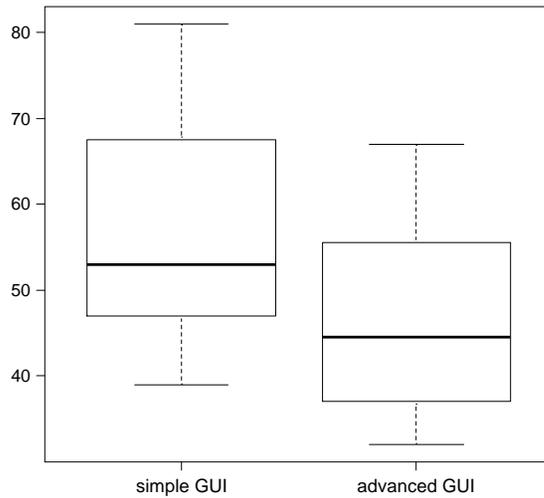
An ANOVA of the time the participants actively spent on drawing (see Figure 7) showed a significant difference between the versions of the GUI tested ( $F_{1,14}=9.9988$ ;  $p=0.0069$ ). People in the advanced GUI condition spent more time of the drawing task.

Multiple ANOVAs of the time the participants actively spent on drawing in each activity (see Figure 8) showed significant differences between the versions of the GUI tested in case of activity 1 ( $F_{1,14}=21.367$ ;  $p=0.0004$ ) and activity 2 ( $F_{1,14}=4.6049$ ;  $p=0.0499$ ).

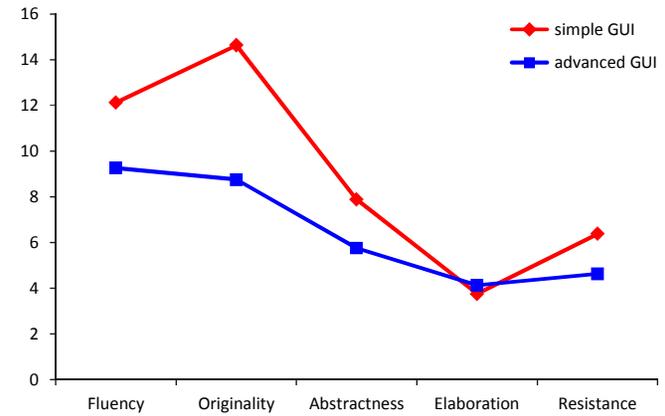
The eraser function available in advanced GUI was used 25 times in total but at least once by 5 of 8 participants. Three of them obtained 20% higher CI scores than their group's average. 3 of 8 participants using simple GUI asked for the eraser functionality.



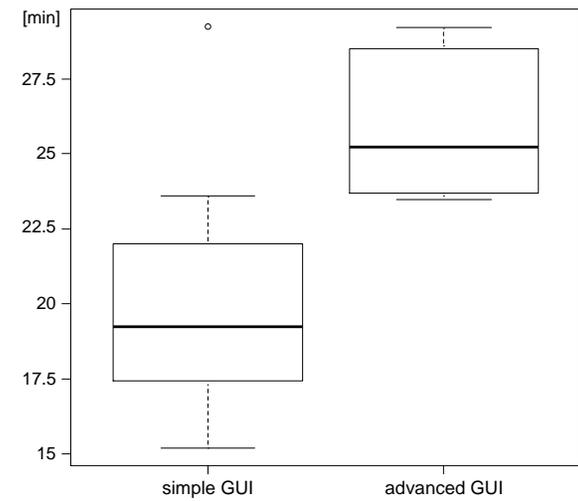
**Figure 4.** CI scores obtained with two versions of the GUI.



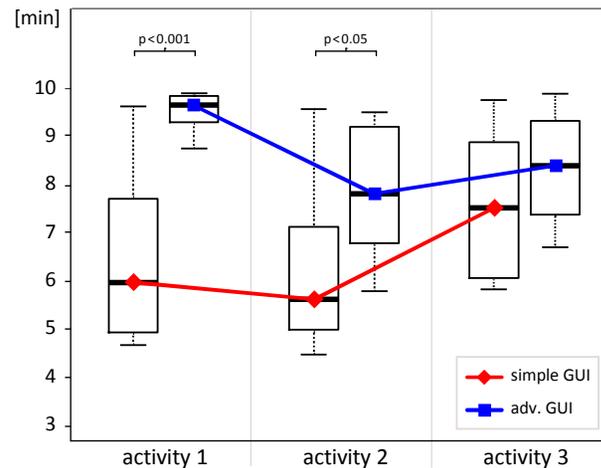
**Figure 5.** Raw scores obtained with two versions of the GUI.



**Figure 6.** Chart of average users' raw scores split into the creative characteristics scored by the TTCT, for both GUIs.



**Figure 7.** Total drawing time measured for both GUIs.



**Figure 8.** Median drawing time for each TTCT's activity measured for both versions of GUI. Horizontal lines denote the p values from ANOVA.

## Discussion

The simple GUI has been previously tested with stylus [20] and it has been found equivalent to the paper and pen. Therefore, the more elaborated advanced GUI might be expected to influence the user's creative performance like in study of Kwon, that is to decrease the scores [18]. However, the difference between the users' scores obtained with the two GUIs tested, were not significant (see Figure 4 and 5) and mostly affecting originality of responses (see Figure 6). Nevertheless, the differences between UI designs might be responsible for 10% difference between the mean raw scores obtained with mouse and stylus (see Figure 1), and 18% of difference between the mean raw scores obtained with simple GUI and advanced GUI (see Figure 5). Therefore, we can expect a cumulative effect of the input device and GUI that potentially might result in significant differences when the simple GUI

would be tested with stylus and advanced GUI with mouse – what would practically replicate the test conditions in the study of Kwon [18].

Each TTCT's activity is graded differently therefore the comparisons of the raw scores between tasks do not make much sense. However, the raw scores summarized per creative characteristics scored by the TTCT showed that the users' fluency and originality are mostly affected in case of advanced GUI.

The eraser function gives participants the opportunity to correct their drawings and modify their ideas. Some users of advanced GUI used the eraser and deleted their drawings completely that helped them to shift from the original idea but might be potentially disadvantageous. The users of simple GUI had to deal with ambiguity and simplicity of GUI combined with the imprecision of the input device. They also had to anticipate their errors or work with the consequences of drawing errors and imperfections that had to be incorporated into the drawing - what made it a subject of constant creative reinterpretation. That opened the possibility of different meanings arising out of changing context and allowed the ideas to be constantly changed.

This phenomenon is also reflected in the drawing time (see Figure 7 and 8). Analysis of time usage revealed that the time spent on actual drawing was significantly higher in case of advanced GUI. The users of simple GUI spent more time on creative thinking and that resulted in higher creativity scores especially in the first two activities that benefited from the original and in-depth representation of an object, scene, or situation.

## Conclusion

Creativity is the basis for inventive problem solving and nowadays that also takes place in computerized

environments. In the presented study we observed the effects of the advanced GUI design on the users' creative performance in the drawing task – those were insignificantly smaller users' raw scores and Creativity Indexes with significantly more time spent on actual drawing in the activities requiring the in-depth presentation of an original idea.

Access to digitized results of the user's creative work is a central feature of the test software used in this study. However, the phenomena observed here might be even more prominent in other drawing applications used e.g. in graphics design where we could expect a cumulative effect of the input device and GUI used.

We have to assume that these results are true in the context of the computer-based creativity testing application but we can conclude that complicated UI design and advanced functionality offered can affect users in many ways and have to be carefully introduced to the computer-based tasks involving users' creativity.

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