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Testing the Usefulness of Information Visualization in Managerial Decision-Making in Work-From-Home Mode

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ABSTRACT

This study aims to examine the effect of information visualization and Need for Cognition (NFC) on usability in work from home (WFH) context. This study uses experimental method with modified case instruments from previous studies. Research results show that there is no difference in the level of efficiency, effectiveness, and satisfaction of information visualization between individuals who complete assignments using high visualization compared to individuals who complete assignments using low visualization. Meanwhile, as hypothesized, there are differences in the level of efficiency, effectiveness, and satisfaction of information visualization between individuals who have high NFC compared to individuals who have low NFC in completing work-from-home assignments. Implications of this result is discussed further for management of organization in remote working context.

Keywords: effective, efficient, satisfaction, information visualization, NFC, WFH.

INTRODUCTION

The condition of the COVID-19 pandemic has moved companies to make decisions to carry out work remotely, this is commonly referred to as work from home (WFH). Gartner's (2020) survey of 229 Human Resources (HR) departments shows that around half of companies had more than 80% of employees working from home during the early stages of the COVID-19 pandemic and showed substantial long-term improvements for remote work after the pandemic. The need for millions of workers to work from home (WFH) in response to COVID-19 has accelerated the recent trend of remote work facilitated by increased connectivity and communication technology. Remote work can determine job expansion, as well as the overlap between personal life and work commitments (Hyman and Baldry, 2011). This creates more contamination between personal and work life, which is likely to involve rather than prevent life-to-work conflict (Foner and Stache, 2012). This can lead to work-to-life conflict in the form of disturbing work-related worries in daily life activities (Sarbu, 2018). Remote work is a broader category as it can include working from anywhere (i.e. not necessarily at home), we know some professionals who need to perform complex tasks that require little interaction with colleagues actually prefer and be more productive if they work from home (WFH) (Allen et al., 2014). Although teleworking from home is considered less common in the public sector (Mohalik et al., 2019), the COVID-19 pandemic made work arrangements applicable to public sector organizations worldwide (ILO, 2020). The need for millions of workers to work from home (WFH) in response to COVID-19 has accelerated the recent trend of remote work facilitated by increased connectivity and communication technology.

The discipline of information visualization is gaining increasing attention (Dilla and Raschke, 2015) because its goal is to identify and create different images by suppressing specific tasks or data features to facilitate understanding (Lurie and Mason, 2007). Information visualization is very helpful in this regard, especially for accounting management because its purpose is to provide internal and external insights about the past, present, and future of the company. Visualization tools, trends, correlations, and deviations can be localized in an efficient and effective way, of course, if the data set grows larger and becomes more complex (Falschlunger et al., 2016).

This research is a development of the research by Perkhofer et al. (2020) research measuring the effect of using appropriate visualization based on the characteristics of the data and the task, specifically examining the interaction features because it is said to be an important component of Big Data visualization. The results show that both having appropriate visualizations based on task characteristics and using interaction features greatly improve usability. Meanwhile, in the process of working on remote assignments, cognitive aspects are also needed. Individuals have a tendency to be involved and enjoy trying cognitive activities, this is called the Need for Cognition (NFC) (Cacioppo and Petty, 1982 in Carnevale et al, 2011). A study by Carnevale et al, (2011) showed that those with leadership experience can overcome psychophysical-based mistakes with process improvement. While it is possible in principle to treat strategy-based errors in a similar way, more research is needed to determine when this would occur among those with a chronic tendency to think deeply.

Previous research measured the effect of using appropriate visualization based on data and task characteristics. This research will examine the use of information visualization in

managerial tasks carried out in work-from-home (WFH) mode. Due to the role of individual cognitive aspects in decision-making, it is necessary to carry out further analysis of the effect of information visualization on usability. Besides being tested on information visualization, they will also feel the effect of the Need for Cognition (NFC) on usability. The results of this study are expected to improve the quality of managerial tasks and decisions in supporting the work-from-home (WFH).

Dependent Variable

The dependent variable in this study is usability. In general, the notion of usability is an attribute of quality that is used to evaluate how easy an interface is to use and is measured by the level of efficiency, effectiveness, and satisfaction (ISO 9241-11:1998 in Bevan et al, 2015). The variable in this study was measured by efficiency obtained from the number of correct answers divided by the number of questions, effectiveness obtained from the number of correct answers divided by the number of questions, and satisfaction obtained from the average of all questions given.

Independent Varible

a. Information Visualization
   This visualization is manipulated by providing visualized information in the form of graphs and tables (Hutchinson et al., 2010). It consists of two levels, namely high visualization and low visualization (Perkhofer et al., 2020). In this study, participants will be given 2 treatments, namely high visualization and low visualization. High visualization will present information in the form of tables and graphs with 11 questions. Meanwhile, low visualization will present information in tabular form and be given 11 questions.
b. Need for Cognition (NFC)
   NFC measurement refers to the instrument developed by Petty and Cacioppo (2020). Participants will provide 10 questions related to Need for Cognition using a Likert scale of 1-5 (strongly disagree, disagree, neutral, agree, strongly agree)

Hypothesis Formulation

Effect of Usability Information Visualization on Information Visualization in WFH Contexts

Visualization has been identified as useful for information processing since the 1970s. This happens because information visualization supports specific features of the data as well as various decision-making abilities (Lurie and Mason, 2007). The mental processes that support human behavior and experience are characterized by the Dual Coding Theory (Paivio, 1971; 1986 in Clark and Paivio, 1991). The collective action of nonverbal and verbal mental systems, each designed to process images and linguistic information, is how the Dual Coding Theory explains psychological phenomena (Clark and Paivio, 1991).

Brink and Lee (2016) acknowledge that image or graphic visualization can help explain complex information by highlighting patterns. However, potential problems may come from this visualization construct (Padilla et al. 2018). The use of information visualization to support the work from home (WFH) process is theoretically expected to improve the quality of managerial tasks and decisions. However, the results of previous research show empirical results that there may be different levels of usability for information visualization, for example in big data visualization (Perkhofer et al., 2019, 2020). So it is necessary to carry out further analysis of the effect of information visualization on usability, so that the expectation that the task and quality of decisions will increase with the support of

these factors has a valid basis. The results of Perkhofer et al's research in 2020 regarding information visualization showed that participants chose the appropriate visualization based on task characteristics and used interaction features, greatly increasing usability. The usefulness of information visualization (usability) is measured through three aspects, namely efficiency, effectiveness, and the level of user satisfaction (Perkhofer et al., 2020).

Researchers develop hypotheses by developing research results from Perkhofer as follows:

H1a: There are differences in the efficiency level of information visualization between individuals who complete assignments using high visualization compared to individuals who complete assignments using low visualization.

H1b: There are differences in the level of effectiveness of information visualization between individuals who complete assignments using high visualization compared to individuals who complete assignments using low visualization.

H1c: There are differences in the satisfaction level of information visualization between individuals who complete assignments using high visualization compared to individuals who complete assignments using low visualization.

The Effect of Need for Cognition (NFC) on the Usefulness of Information Visualization in WFH Contexts

Need for Cognition is defined as a tendency to engage in and enjoy the effortful cognitive activity (Cacioppo and Petty, 1982 in Carnevale et al., 2011). Individuals with a high Need for Cognition engage in cognitively challenging activities without external motivation, whereas individuals with a low Need for Cognition prefer to engage in cognitive tasks if they have a good reason to do so. Individuals with a low Need for Cognition tend to rely more on simple cues and their stereotypes when making judgments (Haugtvedt, Petty, and Cacioppo, 1992 in Carnevale et al, 2011). Meanwhile, individuals who have a high Need for Cognition will consider all relevant information.

The results of Carnevale et al's research in 2011 showed that individuals who have high NFC can overcome psychophysical-based errors with increased information processing. Need for Cognition (NFC) is a person's tendency to involve themselves and enjoy cognitive activities that can differ from one person to another (Cacioppo and Petty, 1982). For individuals with high levels of NFC, thinking will satisfy them and is something they enjoy. For individuals with low NFC levels, the opposite will occur, thinking is something he does only if there are certain incentives or strong reasons that make it up. The efficient and effective use of visualization needs to be adjusted depending on the situation and the user. The need for adjustments to task characteristics was conceptualized in the 1990s by cognitive appropriateness theory (Vessey, 1991); This theory states that efficient and effective decision-making can only be achieved if the external representation (visualization left to the decision maker or user) matches the user's internal representation (mental representation associated with the decision maker's task).

Based on cognitive suitability theory, high NFC vs. low NFC will respond differently to the visualization of the information it receives. It can be implied that high NFC will correspond to high information visualization, so that the level of usefulness that reflects in individual efficiency, effectiveness, and satisfaction will be different, compared to low NFC individuals. Based on this, the researcher developed the following hypothesis:

H2a: There is a difference in the level of information visualization efficiency between individuals who have high NFC compared to individuals who have low NFC.
H2b: There are differences in the level of effectiveness of information visualization between individuals who have high NFC compared to individuals who have low NFC.
H2c: There is a difference in the satisfaction level of information visualization between individuals who have high NFC compared to individuals who have low NFC.

METHOD

The sampling technique in this study used experiments. This study uses primary data types obtained from instruments that are distributed to all participants. The participants in this study are professionals who are at junior, middle, and senior managerial levels and who are currently working or have worked from home to make internal decisions that are important to the organization. This research will also use student participants from several universities in Yogyakarta and abroad. The use of students as situated subjects should be based on the argument that students as representatives of real managers in industry can be a valid methodological choice (Elliot et al., 2007). The selection of participants was carried out according to the research objectives, in which this study tested the effect of 2 variables on the usefulness of information visualization in the context of working from home. For experimental designs, the accuracy of the participants is determined by the ability of the participants to be able to understand and internalize the treatment or arrest given to them (Nahartyo and Utami, 2016). In this study, questions were given as check checks. Question handling is complemented by supporting data in the form of sales data and advertising costs incurred by the company (Hutchinson et al., 2010).

The data in this study were collected using an experimental instrument with a given case. Researcher used a modification of the case instrument from previous studies, namely Hutchinson et al., (2010). The case instrument will be given to the participants and will later become a source of data for this experimental research. This study uses a network-based experiment (web-based experiment). The method used to obtain data using research instruments is preparation/treatment which is prepared with a series of cases that have been prepared in advance. In this study, a 2×2 factorial design was used, namely information visualization (high and low) and NFC (high and low).

Matrix Experiment

Table 1. Hypothesis Testing Cells

Information Visualization	**NFC**	
	High	Low
High	Cell 1	Cell 2
Low	Cell 3	Cell 4

Based on this matrix, participants will be given 4 different treatment combinations. The following is an explanation of the table in this study:
Cell 1: Receives an assignment with high information visualization and high NFC

Cell 2: Receives an assignment with high information visualization and low NFC
Cell 3: Receives an assignment with low information visualization and high NFC
Cell 4: Receives an assignment with low information visualization and low NFC

Case

In this study, participants will be divided into 4 case groups:
1. Participants who receive high information visualization and enter high NFC
2. Participants who receive high information visualization and enter into low NFC
3. Participants who receive low information visualization and enter into high NFC
4. Participants who receive low information visualization and enter into low NFC

In this experimental research instrument, data will be presented in the form of tables and graphs. High information visualization will present data in the form of graphs and tables, while low information visualization will only present data in the form of tables.

Manipulation Check

In this study, manipulation was carried out by distributing research links to participants. Manipulation checks were carried out in stages. The first stage was checking the participants' understanding of the data provided. The data provided is in the form of sales data and past period advertising costs incurred by the company for 3 types of media, namely Youtube, Facebook, and Instagram. These questions are presented with data in the form of tables for low visualization, and data in the form of tables and graphs for high visualization. Participants are said to pass manipulation if they can answer at least 6 of the 9 questions correctly and correctly. By themselves, participants must be able to analyze which of the three media's advertising costs has the same trend as the sales trend that occurs. Furthermore, checking the manipulation of the implementation of the data provided regarding information visualization, where participants must complete all assignments completely.

Experimental Procedure

Experimental procedures help researchers to ensure experimental designs are carried out in an orderly manner, so as to provide maximum benefit. The experimental procedure carried out in this study is as follows:

a. Messages were sent to the participants (managers and students), including a link to enter the experimental assignment application.
b. The network application used is Survey Monkey.
c. Participants enter the experimental application and immediately follow the description in the simulation.

Randomization

There are 4 types of processing consisting of A (high information visualization with high NFC), B (high information visualization with low NFC), C (low information visualization with high NFC), and D (low information visualization with low NFC). Links for each container/case were sent to target participants and randomly selected. One participant can only fill one case.

RESULT AND DISCUSSION

Table 2. Number of Participants for Each Treatment Before and After Checking Manipulation

Case	Number of Participants	Percentage
A	28	35,9%
B	15	19,2%
C	23	29,5%
D	12	15,4%
Amount	78	100%
Passed Manipulation Check		
A	7	22,6%
B	9	29,0%
C	10	32,3%
D	5	16%
Amount	31	100%

Characteristics of participants based on male gender were 13 people with a percentage of 41.9%, while participants with female gender were 18 people with a percentage of 58.1%. The age range of participants was mostly born between 1995-2010, namely 17 people with a percentage of 54.8%. Meanwhile, there were 14 participants born between 1981-1994 with a percentage of 45.2%. The number of participants from practitioners was 24 people with a percentage of 77.4% and students there were 7 people with a percentage of 22.6%.

Table 3. Efficiency Descriptive Statistics

Dependent variable: Efficiency

Information Visualization	**NFC**		**Amount**
	High	**Low**	
High	**1** Mean: 3,86 SD: 0,378 N: 7	**2** Mean: 3,11 SD: 0,601 N: 9	Mean: 3,44 SD: 0,629 N: 16
Low	**3** Mean: 3,50 SD: 1,080 N: 10	**4** Mean: 2,8 SD: 0,837 N: 5	Mean: 3,27 SD: 1,033 N: 15
Amount	Mean: 3,65 SD: 0,862 N: 17	Mean: 3,00 SD: 0,679 N: 14	

Source: Output SPSS

Based on the table, it is known that the average efficiency in each experimental group. The average efficiency of high information visualization and high need for cognition (NFC) has the highest score of 3.86. Of the 31 participants, the level of efficiency in high and low need for cognition (NFC) conditions and high and low information visualization resulted in an average of 3.65 and 3.00 as well as 3.44 and 3.27

Table 4. Effectiveness Descriptive Statistics

Dependent variable: Effectiveness

Information Visualization	NFC		Amount
	High	Low	
High	**1** Mean: 3,86 SD: 0,378 N: 7	**2** Mean: 3,33 SD: 0,707 N: 9	Mean: 3,56 SD: 0,629 N: 16
Low	**3** Mean: 3,50 SD: 1,080 N: 10	**4** Mean: 2,6 SD: 0,548 N: 5	Mean: 3,20 SD: 1,014 N: 15
Amount	Mean: 3,65 SD: 0,862 N: 17	Mean: 3,07 SD: 0,730 N: 14	

Source: Output SPSS

As seen in the table it can be seen that the average effectiveness in each experimental group. The average effectiveness of high information visualization and high need for cognition (NFC) has the highest value, namely 3.86. Of the 31 participants, the level of effectiveness in high and low need for cognition (NFC) conditions and high and low information visualization resulted in an average of 3.65 and 3.07 as well as 3.56 and 3.20.

Table 5. Satisfaction Descriptive Statistics

Dependent variable: Satisfaction

Information Visualization	NFC		Amount
	High	Low	
High	**1** Mean: 3,71 SD: 0,756 N: 7	**2** Mean: 3,11 SD: 0,601 N: 9	Mean: 3,37 SD: 0,719 N: 16
Low	**3** Mean: 3,50 SD: 1,080 N: 10	**4** Mean: 2,8 SD: 0,837 N: 5	Mean: 3,27 SD: 1,033 N: 15
Amount	Mean: 3,59 SD: 0,939 N: 17	Mean: 3,00 SD: 0,679 N: 14	

Source: Output SPSS

Based on the table, it can be seen that the average satisfaction in each experimental group. The average satisfaction with high information visualization and high need for cognition (NFC) has the highest value, which is equal to 3.71. Of the 31 participants, the level of satisfaction with the high and low need for cognition (NFC) conditions and high and low information visualization resulted in an average of 3.59 and 3.00 as well as 3.37 and 3.27.

Table 6. Efficiency Anova Test

Dependent variable: Efficiency

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4,051a	3	1,350	2,139	0,119
Intercept	317,792	1	317,792	503,365	0,000
Visualisasi Informasi	0,806	1	0,806	1,277	0,268
NFC	3,775	1	3,775	5,979	0,021
Visualisasi Informasi* NFC	0,004	1	0,004	0,006	0,939
Error	17,046	27	0,631		
Total	370,000	31			
Corrected Total	21,097	30			

Source: Output SPSS

Based on the results obtained above, it is known that the information visualization test has a sig value of 0.268 > 0.05, so there is no difference in efficiency between individuals who receive high information visualization and those who receive low information visualization. The sig value on the need for cognition (NFC) is 0.021 <0.05 so there is a difference in decision-making efficiency between those who are given a high need for cognition (NFC) assignment and those who are given a low need for cognition (NFC) assignment. The main effect of information visualization is not significant and the main effect of the need for cognition (NFC) is significant. Meanwhile, the interaction is not significant. The results of the ANOVA test in testing hypothesis 1a, show that the value of the main effect of information visualization is 0.268, which means it is not significant and the average efficiency value between high information visualization is different from low visualization, namely 3.44 and 3.27. So hypothesis 1a is not supported. The results of the ANOVA test in testing hypothesis 2a show that the main effect of the need for cognition (NFC) is 0.021 which is significant, the mean efficiency value for a high need for cognition (NFC) is different from the low need for cognition (NFC), namely 3.65 and 3.00 then hypothesis 2a is supported.

Table 7. Effectiveness Anova Test

Dependent Variable: Effectiveness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4,798a	3	1,599	2,608	0,072
Intercept	318,857	1	318,857	519,966	0,000
Visualisasi Informasi	2,147	1	2,147	3,500	0,072
NFC	3,659	1	3,659	5,968	0,021
Visualisasi Informasi * NFC	0,255	1	0,255	0,417	0,524
Error	16,557	27	0,613		
Total	377,000	31			
Corrected Total	21,355	30			

Source: Output SPSS

The test results in the table show that the sig value for information visualization is 0.072 > 0.05, so there is no difference in effectiveness between individuals who receive high information visualization and those who receive low information visualization. Meanwhile, the sig value for the need for cognition (NFC) is 0.021 <0.05 so there is a difference in decision effectiveness between individuals who complete assignments with a high need for cognition (NFC) and those who complete low need for cognition (NFC) assignments. The main effect of information visualization is not significant, while that of the need for cognition (NFC) is significant. Meanwhile, the interaction is not significant. The results of the ANOVA test in testing hypothesis 1b show that the value of the main effect of information visualization is 0.072, which means it is not significant and the mean value of effectiveness between high information visualization and low information visualization is 3.56 and 3.20. So hypothesis 1b is not supported. The results of the Anova test in testing hypothesis 2b show that the value of the main effect of need for cognition (NFC) is 0.021 so it is significant, the mean value of effectiveness for high need for cognition (NFC) is different from the low need for cognition (NFC), namely 3.65 and 3, 07 so that hypothesis 2b is supported.

Table 8. Satisfaction Anova Test

Dependent variable: Satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3,157a	3	1,052	1,448	0,251
Intercept	310,985	1	310,985	428,017	0,000
Visualisasi Informasi	0,498	1	0,498	0,686	0,415
NFC	3,066	1	3,066	4,219	0,050
Visualisasi Informasi * NFC	0,017	1	0,017	0,023	0,880
Error	19,617	27	0,727		
Total	365,000	31			
Corrected Total	22,774	30			

Source: Output SPSS

The table above is the result of the satisfaction Anova test, in the table it can be seen that the visualization test shows a sig value of 0.415 > 0.05. This means that there is no difference in satisfaction in making decisions between individuals who receive tasks with high information visualization and those who receive tasks with low information visualization. The need for cognition (NFC) test has a sig value of 0.050 = 0.05, so there is a difference in the level of decision satisfaction between individuals who complete tasks with a high need for cognition (NFC) and individuals who complete tasks with a low need for cognition (NFC). cognition needs (NFC). The main effect of information visualization is not significant, while the main effect of the need for cognition (NFC) is significant. While the interaction is not significant. In testing hypothesis 1c, the results of the ANOVA test showed that the value of the main effect of information visualization is 0.415, which means it is not significant. The average value of high information visualization is different from low information visualization satisfaction, namely 3.37 and 3.27. So hypothesis 1c is not supported. The results of testing hypothesis 2c, show that the value of the main satisfaction effect on the ANOVA test is 0.050, which means it is significant. so that hypothesis 2c is supported.

DISCUSSION

Effect of Usability Information Visualization on Information Visualization in WFH Contexts

Based on the analysis that has been done, the results of the study show that there is no difference in the level of efficiency, effectiveness, and satisfaction of information visualization between individuals who complete tasks using high visualization compared to

individuals who complete tasks using low visualization. This could be because people are used to working remotely, so people are used to using visualization for work. In line with the Multiple Coding Theory which proposes that cognition consists of two distinct sub-systems, one for representing and processing non-verbal information and the other for dealing with language, these systems are separate but interconnected (Sadoski et al, 2012). Perkhofer et al.'s research, (2020) that the type of visualization used and the level of interaction affect efficiency and satisfaction, while the type of task has the most influence on effectiveness. In order for users to make effective decisions, the task being organized needs to be supported by a type of visualization. These results can be seen as general guidelines for the use of visualization in the context of managerial accounting.

The Effect of Need for Cognition (NFC) on the Usefulness of Information Visualization in WFH Contexts

There are differences in efficiency, effectiveness, and satisfaction levels of information visualization between individuals who have high NFC compared to individuals who have low NFC in completing work-from-home tasks. Researchers assume that NFC has a different satisfaction impact when participants are given high or low information visualization. Participants who have a high need for cognition (NFC) when given tasks using high or low information visualization will get higher results than participants who have a low need for cognition (NFC). Participants who have a low need for cognition (NFC) when receiving assignments using high or low visualization have lower results than participants who have a high need for cognition (NFC).

Individuals who have a low Need for Cognition tend to rely more on simple cues and their stereotypes when making judgments (Haugtvedt et al, 1992 Carnevale et al, 2011). Meanwhile, individuals who have a high Need for Cognition will consider all relevant information. This is in accordance with cognitive suitability theory which states that efficient and effective decision making can only be achieved if the external representation (visualization delivered to the decision maker or user) matches the internal user representation (mental representation related to the decision maker's task).

IMPLICATIONS

Theoretical Implications

This research can strengthen cognitive suitability theory (Vessey, 1991), in that the use of visualization that is efficient and effective needs to be adapted to the user's situation. In the current COVID-19 pandemic situation, managers are encouraged to carry out activities remotely, one of which is making decisions. This will affect managerial conditions in making decisions. In complex decision-making situations, managers can be facilitated with information visualization so that they can improve the quality of decisions, in terms of efficiency, effectiveness, and satisfaction.

Practical Implications

The results of this study can be used as a reference for company management to present information used as a basis for decision-making. Information presented visually will facilitate management in analyzing and making decisions.

CONCLUSION

The purpose of this study is to examine the differences in decisions taken by managers when faced with information visualization and the need for cognition (NFC). This study used research samples, namely professionals/practitioners and students who were or were working on assignments using the work-from-home (WFH) method. Working remotely is common nowadays, so people are used to it. The researchers concluded that visualizing information in the context of working remotely increases usability. When decision-makers are familiar with remote information visualization, there is no effect of information visualization on usefulness in decision-making. However, a person's cognitive aspect differs in its usefulness in decision-making. This is because each person has a different cognitive level, which the cognitive aspect influences when making decisions.

The limitations of this study include the assignment of experiments given to participants through the monkey survey application so that participants cannot be monitored directly; participants need a long time to complete the task properly and correctly; internet access must be stable when accessing the monkey link survey provided so that the data can be displayed in full. Further research could be conducted by retesting different participants, experimental assignments must be given directly so that participants succeed in completing assignments to the end, testing the effect of various types of information visualization that are more diverse and in accordance with the times.

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