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A Survey Study for The Comparison of Meta-Analysis Softwares

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ABSTRACT

In recent years, meta-analysis studies have become a popular field of study in order to quantitatively analyze the results obtained from more than one study carried out independently from the same subject and to interpret the results from a holistic perspective. Because of this reason, different licensed and open source software has been developed in the last 20 years. With this study, it is aimedThis study aims to compare the existing programs and software in terms of meta-analysis in terms of quantitative and qualitative aspects. For this purpose, the results obtained from Jamovi, CMA, RStudio and Meta-Essentials programs were compared within the determined criterias. As a result of filtering the 1906 studies obtained from databases in accordance with the flow diagram, the number of studies to be included in the meta-analysis was determined to be 32. As a result of the study, it was found that forest plots obtained from different programs do not differ according to the program used. In addition, the open source and free of R, Jamovi and Meta-Essentials programs have been determined as the superiority of the programs compared to CMA. According to the findings, Jamovi has much more test for heterogeneity compaired to the other softwares. At the same time, the number of model prediction options is much higher for Jamovi compared to Meta-Essentials and CMA. While the other software does not provide any information regarding model fit index and information criterion, Jamovi offers a rich output in this regard. It can be said that these features make Jamovi advantageous over other software.

Keywords: Meta-analysis, RStudio, Jamovi.

Meta-Analiz Yazılımlarının Karşılaştırılmasına İlişkin Bir Tarama Çalışması

ÖZ

Son yıllarda, aynı konuya ilişkin bireysel çalışmaları nicel olarak analiz etmek ve sonuçları bütüncül bir perspektiften yorumlamak için meta-analiz çalışmaları popüler bir çalışma alanı haline gelmiştir. Bu nedenle, son 20 yılda farklı lisanslı ve açık kaynaklı yazılımlar geliştirilmiştir. Bu çalışma ile mevcut programların ve yazılımların meta-analiz açısından nicel ve nitel açıdan karşılaştırılması amaçlanmıştır. Bu amaçla Jamovi, CMA, RStudio ve Meta-Essentials programlarından elde edilen sonuçlar belirlenen kriterleri temel alarak karşılaştırılmıştır. Veri tabanlarından elde edilen 1906 çalışmanın akış diyagramına göre filtrelenmesi sonucunda meta-analize dahil edilecek çalışma sayısı 32 olarak belirlenmiştir. Çalışma sonucunda farklı programlardan elde edilen orman grafikleri kullanılan programlar bazında göre farklılık göstermemiştir. Özellikle de R programının CMA karşısında bütüncül anlamda değerlendirildiğinde daha gelişmiş özelliklere sahip olduğu sonucuna ulaşılmıştır. Bulgulara göre, diğer yazılımlarla karşılaştırıldığında Jamovi kapsamında çok fazla heterojenlik testi yapılabildiği; model tahmin seçeneklerinin sayısının Jamovi için Meta-Essentials ve CMA'ya göre çok daha yüksek olduğu; diğer yazılımlar model uyum indeksleri hakkında herhangi bir bilgi sağlamazken Jamovi'nin bu konuda zengin bir çıktı sunduğu sonucuna ulaşılmıştır.

Anahtar kelimeler: Meta-analysis, RStudio, Jamovi.

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1 | INTRODUCTION

Meta-analysis, which is sometimes characterized as “scientific chaos” in the scientific world, is a subject on which very heated discussions are held (Eysenck, 1994; Hunt, 1997; Bax et al., 2007). Meta-analysis is defined as a quantitative method used to combine information through interrelated but independent studies (Normand, 1995; Hedges and Olkin 1985). Meta-analysis methodology is old enough to be based on Birge (1932) and Pearson (1904) (Normand, 1995). The significance of meta-analysis as a quantitative part of the systematic review, lies in the formal and reproducible analysis of the heterogeneity on the effect sizes of the small-size studies and other data indices (Bax et al., 2007). Meta-analysis is used in the context of many different applications today, from the process of combining knowledge in the field of astronomy to the synthesis of research results in social sciences.

Conducting a meta-analysis study requires combining information and summarizing evidence through the studies independent in terms of process. If there are numerous studies on a hypothesis established by a researcher, the researcher can achieve a clearer and single result by approaching these studies methodologically. This is one of the reasons that strengthen meta-analysis (Egger et al., 1997: 1998). Trying to determine the statistical significance of the differences between two groups from a single study is not reliable enough. Type I and Type II errors are the types of errors that every researcher want to avoid at all costs and meta-analysis attempts to overcome such a situation (Fagard et al., 1996). Generalization of the results obtained by a meta-analysis study means that the variations of different groups are included in the analysis process by including different populations. This makes more sense than the generalization made with a single study (Borenstein et al., 2009; Harrer et al., 2022). At the same time, the review process on the topic performed by meta-analysis and the holistic evaluation of the researches provide a statistically reliable approach and thus the results are quite far from subjective judgments (Lipsey & David, 2001; Pigott, 2012; Eser & Yurtçu, 2020).

Besides the strong points of meta-analysis, criticisms targeting meta-analysis are related to the reliability of meta-analysis studies, behind which the concept of “bias” lies. According to Egger, Davey Smith (1997), publication bias, database bias, citation bias, multiple publication bias, bias related to data collection, and bias related to setting criteria pose a threat for meta-analysis studies.

Similar to the researches studies in which non-meta-analysis methods are used, there are three basic steps in meta-analysis: (1) creating the research question; (2) collecting and analyzing the data; and (3) reporting of the research results (Egger et al., 1997; Lipsey & David, 2001). There are some important steps to ensure that the measurement results of a meta-analysis study are valid and reliable. According to Egger, Smith and Phillips (1997) these steps are: (1) setting the criteria of the data to be collected; (2) defining a strategy for determining the studies to be included in the research; (3) establishing a standard form for data collection; (4) standardizing the statistics to compare the studies included in the research; (5) combining data to calculate overall impact.

There is no single software that is best for everyone. The most appropriate software for a researcher depends on the researcher's request. Today, computer softwares related to meta-analysis are very important. It should be noted that in the last 15 years important softwares used in meta-analysis were produced. Among them, the most remarkable ones are of course free softwares and free tools. Free software philosophy is based on producing and sharing. Free software is the type of software that gives the user the freedom to operate, copy, distribute, review, change and develop the program. Although being free of charge it is perceived as the biggest factor in choosing a software, the characteristics of analytical models and graphs, validity or comparability of results, ease of use and usability are as important as being free of charge (Fagard et al., 1996; Eser et al., 2020).

Departing from the free software philosophy, which is based on producing and sharing, it was aimed in the study to compare two different free softwares, a free tool and a commercial software used for meta-analysis, which is one of today's popular research topics, from different aspects. The research is thought to contribute to reducing the tendency of using non-free meta-analysis software in publications involving meta-analysis, especially in the national literature. This study also aims to raise awareness about the availability of various free softwares and tools for meta-analysis. Although the main purpose of the study is the comparison of the softwares, some criteria have been taken into consideration in the selection of the publications to be included to ensure the originality of the data sets and the interpretability of the study in a theoretical sense, such as the study should be in English, the sample

size should not be less than 30, and the paper should be published after 2010. The problem statement was expressed as “How does the year of study affect the effect of foreign language anxiety on foreign language achievement?”.

2 | METHOD

In this section, the validity and reliability of the research type, software selection process, data collection process and coding process are discussed.

RESEARCH DESIGN

In this study, the analyzes analyses were performed on a real data using 4 different meta-analysis softwares and these softwares were compared in terms of general features and analysis results. In this regard, the study is a basic research which is aimed to add new information to existing information (Karasar, 2015). The research is thought to have the characteristics of a screening survey research, as it reveals and describes a situation that exists. Screening Survey research aims to describe the characteristics related to individuals or situations as they exist (Fraenkel & Wallen, 2009). The type of analysis performed in the study was correlation-based meta-analysis. In this sense, the effect size of the analyzed studies was based on Pearson Correlation.

SOFTWARE SELECTION PROCESS

Within the scope of the study, Jamovi 1.1.9.0, R-3.6.2, Meta-Essentials 1.5 and CMA 3 softwares were compared. Criteria for the selection of software were set as popularity, being free software, and having/not having a drop-down menu. Jamovi (2018) is a new, free software based on R programming language and the analysis are based on popular R packages and performed via drop-down menus; R (1993) is an old, free and popular software; Meta-Essentials (2015) is a new and free tool; CMA (2000), on the other hand, is a popular and relatively older commercial software where the analysis are performed via drop-down menus. The 10-day free version of the CMA software was used to perform the analysis (Schmidt & Huy, 2005).

DATA COLLECTION PROCEDURE

In order to reach more publications related to the purpose of the study, international publications were accepted as the data source of the study. In this context, publications in the Web of Science and Google Scholar database have been scanned, using the following keywords: ‘Foreign language anxiety’, ‘Foreign language anxiety academic achievement’, ‘Foreign language anxiety academic performance’, ‘Foreign language classroom anxiety’, ‘Second language anxiety’, ‘Second language anxiety academic achievement’, ‘Second language anxiety academic performance’. The criteria determined for the publications were: Publications in which Pearson Correlation was reported (to minimize the amount of error without any need of transformation); publications made in 2010 and after (to ensure the up-to-dateness of the data); studies written in English (to form a database of international studies); publications in which the sample size was reported and having non-small sample size (n> 30). 32 studies were included in the research as a result of the screening conducted according to these criteria. The start date of the screening process is 10.11.2019; the end date is 22.12.2019. The flowchart followed for the data collection process is shown in Figure 1.

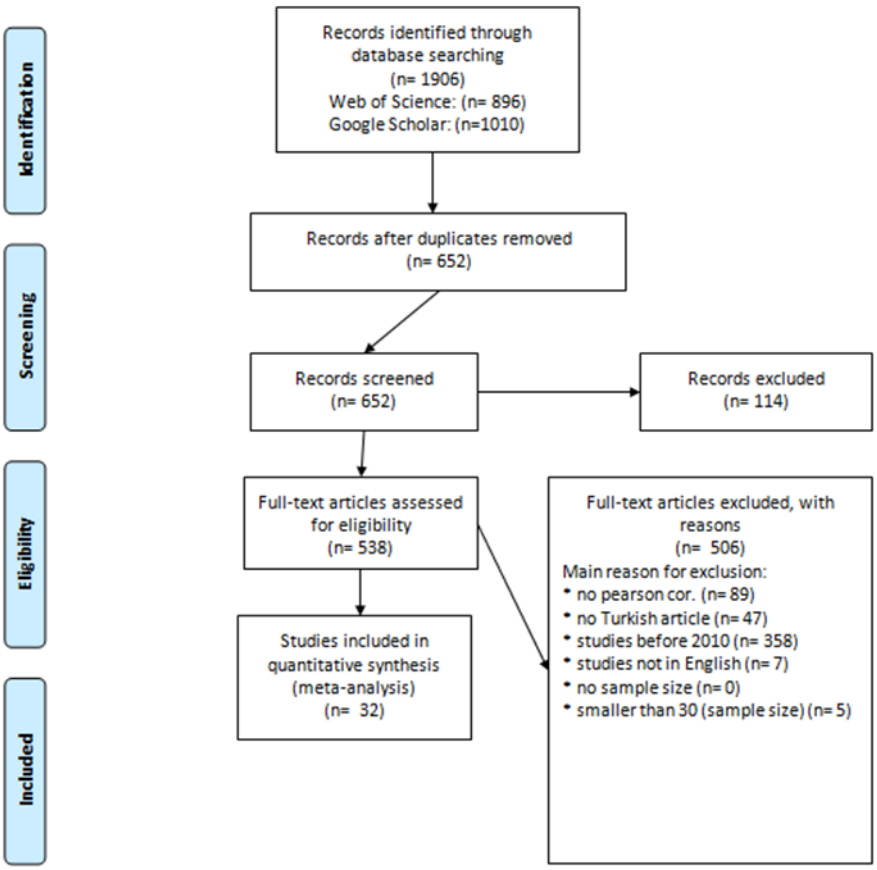

Figure 1. *Flowchart of Data Collection*

In the international literature, it is recommended to use the flow diagram suggested in the PRISMA Statement for systematic review and meta-analysis studies (The PRISMA Group, 2009). The purpose of the PRISMA Statement is to help researchers in improving the presentation and reporting of systematic review and meta-analysis studies. The flowchart of the data collection process is illustrated in Figure 1. The studies included in the meta-analysis are shown in Table 1, as included in the coding form.

Table 1. List of the Studies Included in the Meta-Analysis

Author	N	Effect size	Year
Ujjwal Kumar Halder1	266	-.327	2018
Ujjwal Kumar Halder2	139	-.242	2018
Ujjwal Kumar Halder3	127	-.351	2018
Mahfouz Abdelsattar Abuelfadl	450	.321	2015
Farhad Ghorban Dordinejad and Roghayyeh Moradian Ahmadabad	400	-.472	2014
Riffat-un-Nisa Awan et al.	149	-.273	2010
Farhor Ghorban Dordinejad and Amir Hosein Farjad Nasab	631	-.357	2013
Mostofa Amiri and Behzad Ghonsooly	258	-.348	2016
Masoomeh Salehi and Fahimeh Marefat	200	-0.22	2014
Christopher C. Anyadubalu	318	-.283	2010
Ying Zheng	830	-.450	2010
Yi-Ting Jocelyn Lan	212	-.570	2010
Wang Yao and Li Jingna	92	-.346	2011
Eleina Hewitt and Jean Stephenson	40	-.490	2012
Magdalena Szyszka	48	-.540	2011
Zhongshe Lu and Meilhua Liu	934	-.317	2011
Naser Atasheneh and Ahmad Izadi	60	-.469	2012
Samaneh Serraj and Noreen bt. Noordin1	210	-.214	2013

Samaneh Serraj and Noreen bt. Noordin2	210	-.414	2013
Mona Mohammadi Golchi	63	-.630	2012
Yasser Teimouri et al.	19933	-.360	2019
Rosa Meleno Corchero1	35	-.285	2017
Rosa Meleno Corchero2	103	-.376	2017
Rosa Meleno Corchero3	43	-.142	2017
Berhane Gerencheal1	50	.039	2016
Berhane Gerencheal2	28	-.490	2016
Meihua Liu and Liu Xiangming1	324	-.375	2019
Meihua Liu and Liu Xiangming2	324	-.244	2019
Meihua Liu and Liu Xiangming3	324	-.136	2019
Meihua Liu and Liu Xiangming4	324	-.155	2019
Meihua Liu and Liu Xiangming5	324	-.317	2019
Ya-Chin Tsai and Yi-Chih Li	302	-.325	2012

* If there is more than one effect size in the same study in terms of Pearson correlation, these different effect sizes are indicated by adding numbers to the author names.
* In the meta-analysis, year variable was coded as 1 (for 2010-2014) or 2 (for 2015-2019) and used as intermediary variable.

Table 1 contains information about the sample size, effect size and study year of the studies examined within the scope of the meta-analysis study.

VALIDITY AND RELIABILITY OF THE CODING PROCESS

The coding form created by the researchers was used in the coding process. The coding forms used in the previous meta-analysis studies were reviewed while creating the coding form (Rudy, 2001). Expert opinion was consulted to ensure the content validity of the form. The opinions of 3 experts working in the field of Educational Sciences and having at least one publication related to meta-analysis were taken and as a result of this review the publication date range of the studies to be included in the data set has been changed to 2010-2019. Arrangements have been made in the sections of the explanation form, which were found to be unclear by the experts. Cohen's Kappa Coefficient is used to determine the reliability of the coding forms used in meta-analysis studies (Leary, 2012). In order to determine the reliability of the coding process to be carried out, 8 studies and the coding forms were sent to the experts via e-mail and they were asked to code within the specified period. As a result of the analysis on intercoder reliability, Kohen's Kappa Coefficient was found to be 0.83, where 0.81 or above indicates perfect fit (McHugh, 2012). In the light of this information, the reliability of the coding process was confirmed by the researchers. As a result, the final version of the coding form was used in the research.

RESEARCH ETHICS

This research was evaluated at the meeting (no 84982664-100) by Aydın Adnan Menderes University Educational Research Ethics Committee in 05.03.2020 and found ethically acceptable.

3 | FINDINGS

In this section, findings and interpretation of the survey results comparing the results of the analysis, comparing the features of the software, analyzing the software analytically and scoring the qualitative features of the softwares are discussed.

COMPARISON OF ANALYSIS RESULTS

The analysis results were compared after comparing various features of the softwares. This comparison can also be considered as the validity of the formulas that run in the background of the software while performing meta-analysis. The correlational meta-analysis was performed using the data set in Table 1. In analyses performed by the 4 softwares DerSimonian-Laird estimation (the only option in Meta-Essentials) at 95% confidence interval was kept constant as the model estimation option. Regarding the analysis results, the same outcomes have been reached up to second decimal point in the test results including heterogeneity test results; overall effect size;

estimation range; subgroup analysis results; and meta regression results (single covariate variable). It was found that the results of publication bias analysis (Egger Test) performed by Jamovi, R and Meta-Essentials are the same. The results related to funnel charts were also found to be the same for all programs. It was concluded that the rank correlation test results of Begg and Mazumdar were the same for CMA and Meta-Essentials, whereas the results obtained from Jamovi and R differed from these results by a slight margin due to continuity correction used by these softwares. Rosenthal Failsafe-N numbers were observed to be the same for Jamovi, Meta-Essentials and CMA (no Failsafe-N test is available in R). Orwin Failsafe-N numbers were observed to be the same in CMA and Meta-Essentials and different in Jamovi. No software errors were encountered while performing the analyzes. Although the analysis results obtained by different software within the scope of the meta-analysis study are very close together, the forest graph obtained in the R program is shown in Figure 2, which helps to easily view the results as a whole in terms of being an example.

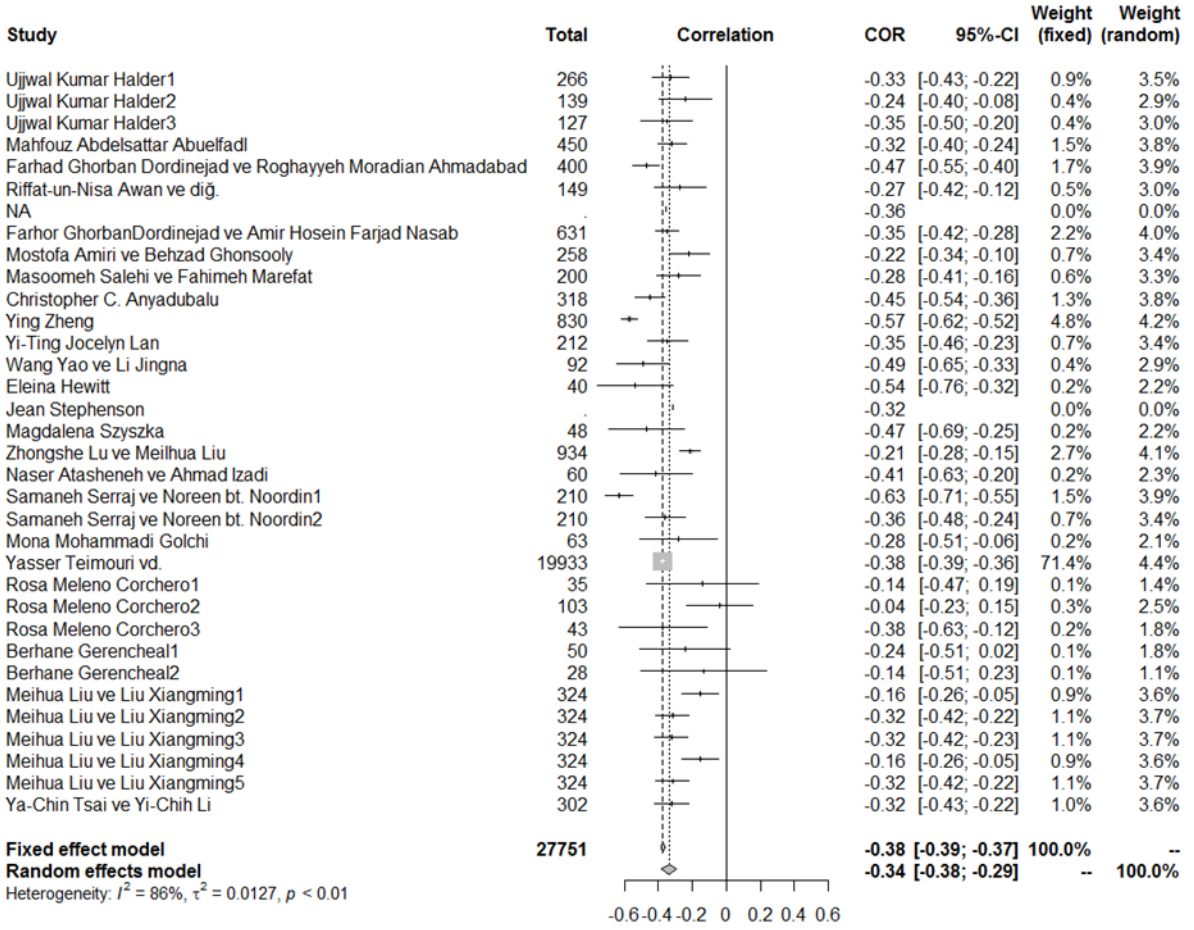

Figure 2. *Forest Graph Results*

In Figure 2, there is a forest chart containing values that will facilitate the interpretation of the combined effect size value of the studies included in the meta-analysis.

COMPARISON OF SOFTWARE RELATED FEATURES

Table 2 contains the features related to the softwares.

Table 2. Features of the Software

General features	Jamovi 1.1.9.0	R-3.6.2 RStudio	Meta-Essentials	CMA
License	Free of charge	Free of charge	Free of charge	Commercial
Open source	Yes	Yes	Yes	No

User Interface	Pop-up Menu	Script	Graphical user interface	Pop-up menu
Prerequisite software	Not available	R (Free)	Microsoft excel	Not available
Program size	186 megabytes	R: 83 megabytes RStudio 1.2.5033: 150 mb	2.2 megabytes	25 megabytes
Compatibility	Windows, Mac OS, Linux	Windows, Mac OS, Linux	Windows, Mac OS	Windows
Web site	www.jamovi.org	www.meta-essentials.com	www.erim.eur.nl	www.meta-analysis.com
Is it only for meta-analysis?	No	No	Yes	Yes
Input features				
Manual data entry	Available	Available	Available	Available
Copy / paste data Set with .xls and .sav extension	Available	Not available	Available	Available
Reading data files in different formats	.omv, .csv, .txt, .sav, .zsav, .por, .dta. .sas7bdat, .xpt, .jasp	.sav, .xls, .sas7bdat, .dta, .txt, .dat, .	.sav, .xls, .dat,	Data can be transferred from programs that display the data set in grid form, such as Excel, SPSS, Stata.
Information sources				
	User guide, website, book	Website, book, help function in the software	User guide, website	Website, book, tutorials
Export options				
Output in APA standard	Yes	Yes	No	No
Copy option	Yes	Yes	Yes	Yes

The first software included in Table 2 is Jamovi. According to Table 2, Jamovi is a free and open source software. Being open source means that users can contribute to the development and modification of the software. In addition to meta-analysis, the software can perform basic and multivariate statistical analyzes and it runs on Windows, Mac OS and Linux operating systems. With these aspects, Jamovi differs from CMA and Meta-Essentials. CMA and Meta-Essentials are the softwares designed for meta-analysis. Similar to R, Jamovi allows direct import of text or other data files. Data sets copied from cell-based programs such as Excel and SPSS can be pasted into Jamovi's dataset window. The software, which has various sources of information about usage, gives outputs in APA standard and researchers can use these outputs with the copy/paste feature. The software differs from CMA and Meta-Essentials in this aspect. The user interface of the software is in the form of drop-down menu, and with this feature, the software differs from R and Meta-Essentials.

The second software included in Table 2 is R. This free and open source software can run on all popular operating systems, it can be used for data mining and machine learning, and it gives outputs in APA standard within the relevant packages. These features distinguish the software from CMA and Meta-Essentials. Although the analyzes can be carried out easily using the packages containing the scripts related to the analyzes, it is required to know the basic scripts needed to use the software and researchers are anxious about using open source softwares, which can be considered as the reasons why R, which is older than CMA, is less popular than CMA, which allow to perform meta-analysis via drop-down menus.

The third software included in Table 2 is Meta-Essentials, which is an Excel-based free meta-analysis tool, it is free of charge and open source, like Jamovi and R. The tool is not as rich as other softwares in terms of information sources, and it doesn't have Jamovi's and R's APA standard output feature. The tool gives simultaneous output after pasting data sets copied from cell-based programs such as Excel and SPSS, which can be thought equivalent of Jamovi's and CMA's ability to perform analysis via drop-down menus and this feature differs the tool from R.

The last software included in Table 2 is CMA, which is the only commercial software among the four softwares. Although CMA is a commercial software, it is the one with the highest profile in the internet search engines, which can be explained by the fact of being one of the oldest meta-analysis software. While other softwares run on almost all operating systems, CMA can only run on Windows based computers, which can be considered as the second restrictive feature of the software. CMA allows direct import of text or other data files such as Jamovi and R. Data sets copied from cell-based programs such as Excel and SPSS can be pasted into the data set window of CMA. Not being open source is one of the most important limitations of the software. The software, which is very rich in terms of information sources, does not give output in APA standard. The user interface design is in the form of a drop-down menu, which makes it easy to use and the software differs from R and Meta-Essentials in this respect.

ANALYTIC COMPARISON OF SOFTWARES

Table 3 contains the analytic features related to the softwares.

Table 3. Analytical Comparison Table of the Softwares

Features	Jamovi	Meta 4.9-9 Package (R Software)	Meta-Essentials	CMA
Decimal places	Available	Available	Available	Available
Confidence interval	Available	Available	Available	Available
Estimation Range	Available	Available	Available	Not
Continuity Correction	Available	Available	Not	Not
Confidence Interval Distributions	Normal or KNHA Student's t	Normal or KNHA Student's t	KNHA Student's t	Normal or KNHA Student's t
Effect Size Calculation	family d and family r	family d and family r	family d and family r	family d and family r
Heterogeneity Test	Q, I^2, Tau^2, H^2	Q, Tau^2	Q, I^2, Tau^2	Q, I^2, Tau^2
Automated Forest Plot	Available	Available	Available	Available
Subgroup-Analyses	Available	Available	Available	Available
Meta-regression	Available	Available	Available	Available
Funnel plot and trim-and-fill	Available	Available	Available	Available
Weighting Methods	Inverse Variance, Mantel-Haenszel, Peto	Inverse Variance, Mantel-Haenszel, Peto	Inverse Variance, Mantel-Haenszel, Peto	Inverse Variance, Mantel-Haenszel, Peto

Model Estimation Options /Estimation of Between Study Variance	Hedges, Hunter-Schmidt, DerSimonian-Laird, Sidik-Jonkman, Maximum likelihood, Restricted Maximum Likelihood, Empirical Bayes, Paula Mendel, Fixed-Effect	Hedges, Hunter-Schmidt, DerSimonian-Laird, Sidik-Jonkman, Maximum likelihood, Restricted Maximum Likelihood, Empirical Bayes, Paula Mendel, Fixed-Effect	DerSimonian-Laird	DerSimonian-Laird, Restricted Maximum Likelihood
Model Fit Indices and Information Criteria	Log-likelihood, Deviance, AIC, BIC, AICc	Not	Not	Not
Model Measurement Options	Raw correlation coefficients, converted correlation coefficients	Raw correlation coefficients, converted correlation coefficients	Raw correlation coefficients, converted correlation coefficients	Raw correlation coefficients, converted correlation coefficients
Failsafe-N Tests	Fail Safe N, Rosenthal, Orwin, Rosenberg	Not	Fail Safe N, Rosenthal, Orwin, Fisher, Gleser & Olkin	Fail Safe N, Orwin
Publishing Bias	Egger Test, Begg & Mazumdar Rank Correlation	Egger Test, Begg & Mazumdar Rank Correlation	Egger Test, Begg & Mazumdar Rank Correlation	Egger Test, Begg & Mazumdar Rank Correlation

The first software included in Table 3 is Jamovi. The first remarkable feature of Jamovi is that the variety of results obtained from the heterogeneity test is wider than other softwares. Jamovi differs from Meta-Essentials and CMA with more diverse model estimation options. While other softwares don't provide any information about model fit index and information criterion, Jamovi provides a rich output in this regard.

The second software in Table 3 is R, in which the analysis was performed using the meta package. Regarding Table 3, it can be seen that a variety of heterogeneity test results could not be obtained for the meta-analysis carried out in the meta package, but the number of model estimation option in the package is the same as Jamovi. This feature can be interpreted as a positive factor for the package. There is no model fit index, information criterion and even Failsafe-N test results related to the analysis output carried out by the package, which can be interpreted as the limitation of the package.

The third tool in Table 3 is Meta-Essentials. The first noticeable feature of Meta-Essentials in Table 3 is that the tool offers only one model estimation option, which can be interpreted as a limitation. At the same time, the tool doesn't give any output regarding model fit index and information criteria. The tool offers rich options in terms of Failsafe-N test compared to other softwares, which can be interpreted as an important feature that distinguishes the tool from other softwares.

The last software in Table 3 is CMA. The first noticeable feature of CMA in Table 3 is that it offers only two model estimation options, which can be interpreted as a limitation. At the same time, the software does not give results regarding any model fit index and information criteria, like Meta-Essentials and R. The results of the analysis conducted with Meta-Essentials 5 and Jamovi can be obtained from 4 different Failsafe-N tests, while CMA gives only the outputs of two statistics related to Failsafe-N test. This fact can be considered as a limitation of the software just like the model estimation option.

COMPARISON OF THE SCORES FOR THE QUALITATIVE FEATURES OF SOFTWARES

7 researchers who have used or who are using all 4 softwares were asked to evaluate the following features of the softwares on a scale from 0 to 10, where 0 indicates "bad" and 10 "excellent": "user interface", "data management", "ease of use", "documentation" and "quality of images". Table 4 includes the average, minimum and maximum values of the scores given by 7 researchers for the softwares under five headings.

Table 4. Meta-Analysis Software – Usability Ratings

	Jamovi	CMA	RStudio[2]	Meta-Essentials
User interface[*]	9.5	7.5	7.6	7.5
Data management	9.3	7.8	8.9	7.8
Ease of use	10	7.6	6.3	7.6
Documentation	9.1	10	10	9.3
Visualizations	8.9	8	8	7.4
Overall score (min-max)	9.36 (8-10)	8.18 (7-10)	8.16 (5-10)	7.92 (7-10)

[*]All scores are mean scores, based on the scores of 'User interface', 'Data management', 'Ease of use', 'Documentation', 'Visualizations' categories. Each item was scored from bad to excellent on a scale from 0 to 10. [2]RStudio IDE has been evaluated within the scope of Meta 4.9-9 package

According to the overall scores in Table 4, which is the average of the scores given by the researchers, Jamovi was observed to be the software with the highest score (9.36) followed by CMA (8.18), RStudio (8,16) and Meta-Essentials (7.92). Jamovi achieved higher average scores than other softwares in terms of user interface, data management, ease of use and the quality of the images, got a lower average score only in terms of documentation. Jamovi is a newer software than others, which can be the reason of this fact. CMA also uses drop-down menus like Jamovi, and the software seems to be easy to use, but in Jamovi the dataset is transferred in fewer steps and Jamovi has a much simpler and easier user interface, which are the main reasons why the overall score of CMA is lower than Jamovi. The analysis carried out in RStudio were using the meta package containing meta-analysis functions, but performing the analysis by using packages is more complex than making them with drop-down menus, which caused the analysis made with RStudio to have a lover score than Jamovi and CMA. Although Meta-Essentials has a higher score than RStudio and the same score as CMA in terms of ease of use, it is in the last place in overall score. As an Excel-based meta-analysis tool, the quality of the images obtained is not as good as other softwares and its limitations in terms of data management causes the Tool's overall score to be lower than others.

4 | DISCUSSION & CONCLUSION

Meta-analysis is an indispensable method for researchers, it is used in synthesizing the results of many studies under one study. Systematic studies carried out within the scope of meta-analysis are at the top of the evidence-based hierarchical formation (Bax et al., 2007). Numerous softwares were developed in the last 20-25 years for meta-analysis, however the review of the literature revealed that there is no research focusing both on the analysis results and the evaluation of the analytical, general and qualitative features of the latest software in a comparative way. Within the scope of the research, some new softwares have been compared with a systematic perspective based on the mentioned criteria.

Analysis results of the research showed that the compared softwares did not make much difference in the analysis results. Although there are some differences in some values obtained from different softwares, these differences tend to be very small and typically occur in the fourth decimal place and do not affect the meta-analysis results. For example, the rank correlation test results of Begg and Mazumdar computed in Jamovi and R (meta package), in which continuity correction is used in the meta-analysis, differ from the results CMA and Meta-Essentials in decimal points.

Regarding the findings of the research about the comparison of software features, Jamovi and R were observed to be free and open source and both software can run on Windows, Mac OS, and Linux operating systems. Both software can give output in APA standard and researchers can use these outputs by copy/paste. Jamovi and R, which were evaluated within the scope of free software, are quite open to the contribution of the users in the development and modification process by definition of free software. It can be said that being free of charge put

both softwares one step ahead of the commercial CMA, which is shown to be as one of the most popular software in the research, and also meta-analysis. CMA runs only on Windows operating system and this feature can be said to be one of the limitations of the software against Jamovi and R that can run on multiple operating systems. The analyzes analyses are performed in Jamovi via drop-down menus and the lack of drop-down menu option for the meta-analysis performed in R can be considered as a limitation of R against Jamovi, CMA and Meta-Essentials. Meta-Essentials which a free meta-analysis tool, is not as rich as R and CMA in terms of information sources, it does not produce outputs in APA standards such as Jamovi and R, and it works only on Windows and Mac operating systems. It can be said that these shortcomings of Meta-Essentials left the software one step behind Jamovi and R, like CMA.

Regarding the findings about the analytic comparison of the softwares, it was observed that the results of heterogeneity test obtained by Jamovi are more diverse than other softwares. At the same time, the number of model estimation options is much higher in Jamovi compared to Meta-Essentials and CMA. While other softwares do not provide any information regarding model fit index and information criterion, Jamovi offers a rich output in this regard. It can be said that these features make Jamovi advantageous over other softwares. Considering as a whole, it can be said that Jamovi is more remarkable than other softwares in terms of analytical features.

According to the overall scoring result of 7 researchers, who have used or who are using the softwares, about the usability of the software under 5 different headings, the ranking was Jamovi, CMA, R and Meta-Essentials. It was observed that Jamovi has a higher average score than other softwares in terms of "user interface", "data management", "ease of use", "documentation" and "quality of images". The reason for Jamovi to score more than other softwares can be cited as: the user interface is very simple and understandable; in addition to performing meta-analysis, it allows to generate basic and multivariate statistics, which enables detailed data management processes to be created.

The review of all the comparisons in the study by the authors in a holistic way shows that Jamovi is ahead of the other softwares. Although CMA appears to be the most used meta-analysis software in the internet databases, the authors of this paper believe that CMA holds such a position because it is quite old, so its recognition is higher, and the analysis is carried out via drop-down menus. Failure to perform meta-analysis via pop-up menus in R and the researchers' prejudices against the softwares in which the analysis is performed using functions, syntax, and command directories rather than pop-up menus were thought to be the reasons why R is positioned behind CMA. Jamovi is free software like R. The first version was released in 2017. The authors of the paper think that this software, which is much newer than CMA, is not sufficiently known. Free softwares such as R and Jamovi are economically and developmentally very important tools for the researchers and universities, when considered on a larger scale. For this reason, it is recommended to expand the use of free softwares. The authors of the paper think that using commercial softwares do not contribute to the researchers in terms of change and development as much as free softwares.

Although this research concluded that there are no significant differences between the results of the softwares, there are differences in the available statistics, features and capabilities of the softwares. Therefore, researchers are recommended to consider the criteria or the results of this and similar studies before deciding the software to be used in the meta-analysis. Moreover, it is suggested to compare different softwares and/or different meta-analysis methods in future studies. As a result, researchers are advised to make the softwares and software procedures they will be used in the future meta-analysis studies an integral part of their studies.

STATEMENTS OF PUBLICATION ETHICS

Throughout this study, research and publication ethics were observed. In all steps of the research, researchers followed the ethical principles. It was evaluated at the meeting (no: E.17615/2020) by Aydın Adnan Menderes University Educational Research Ethics Committee in 05.03.2020 and found ethically acceptable.

RESEARCHERS’ CONTRIBUTION RATE

The first author contributed with data analysis, reported the results and contributed the article revisions. The second author contributed with data analysis and reported the results. All authors contributed to the literature review, read and approved the final article.

CONFLICT OF INTEREST

The authors of this article declare that there is not conflict of interest.

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