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Robustness And Comparative Power Of Welch-Aspin, Alexander-Govern And Yuen Tests Under Non-Normality And Variance Heteroscedasticity

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ROBUSTNESS AND COMPARATIVE POWER OF WELCH-ASPIN, ALEXANDER-GOVERN AND YUEN TESTS UNDER NON-NORMALITY AND VARIANCE HETEROSCEDASTICITY

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بسم الله الرحمن الرحيم

DEDICATION

This dissertation is dedicated to my parents who always believed in the value of education. Their direction instilled an early and persistent interest in the pursuit of higher education. Without their selfless love and whole-hearted support, I will not be what I am today.

To my dear wife, you are the brightest light in my life and you provide me with the direction of my life, and the warmth and support to be a better person. I am so blessed to have you in my life and to receive your love and kindness.

To my lovely daughter Eileen and my son Abdullah.

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CHAPTER 1 INTRODUCTION

Testing the equality of independent group means under assumption violations has been a persistent problem in educational and psychological research (Wilcox, 1996). During the last half-century, numerous statistical tests, including parametric and nonparametric tests, have been used to test the equality of means across independent groups (Scheffe, 1959). Considerable attention has been paid to the performance of parametric tests, such as ANOVA F test and *t* test in the literature for assumption violations, heterogeneous variances and non-normality. The problem of testing for means equality when the assumptions of variance homogeneity and normality are violated has been investigated in early literature dates back to the time of Fisher (1935). Under these testing methodologies, the probability of Type I errors increases along with statistical power reduction when a larger variance is associated with a smaller sample size as well as non-normal data distribution (Clinch & Keselman, 1982).

It is known that parametric statistical tests depend on a number of assumptions about the population from which samples in the test are drawn. (Kerlinger, 2000). The use of parametric tests with violations to their underlying assumptions will affect their efficiency and ability to control the Type I error rates, as well as maintain a satisfactory level of statistical power (Syed, 2006).

Although predominantly used in applied research analysis, especially when assumptions for parametric tests were not met, nonparametric tests do not rely on assumptions regarding population parameters. This preference stems from their robustness against violation on normality. When a population's distribution is non-normal, the Wilcoxon rank sum test for instance, as a nonparametric test is more powerful than the parametric t-test (Lehman &

D'Abrera, 1975).

Non-normality and heteroscedasticity violations are common problems encountered when using common classic or conventional tests. Classic tests are sensitive to violations of their standard statistical assumptions, for instance normality and homogeneity of variances, although they remain serviceable if violation of these assumptions can be remedied (Wilcox & Keselman, 2003).

Consideration was given to the condition of non-normality, specifically when the studied groups had dissimilar distribution shapes. It is rare to encounter comparisons in which one group has an approximately normal distribution and the other group has a skewed distribution in most behavioral, educational, and psychological fields (Chen, 1995). Micceri (1989) surveyed 440 data sets from educational and psychological literature and none of the distributions could be characterized as normal. Most of distributions examined had asymmetry in terms of skewness and excessive or low kurtosis. Most of the previous studies using the *t*-test failed in terms of robustness with such distributions (Micceri, 1989).

With respect to Micceri (1989) study findings, Sawilowsky and Blair (1992) conducted a simulation study to explore Type I error rates for the *t*-test using combinations of non-normal populations. Results indicated the *t*-test performed well and was robust to Type I error, in particular with mild to moderate non-normal distributions and large sample size (approximately $n = 30$). It was revealed the *t*-test was not robust with extreme skewed and kurtosis distributions (Sawilowsky, 1992).

In terms of detecting change in scale and finding solutions for the violation of assumptions of variance homogeneity and normality problem, statistical tests were designed for the purpose of detecting scale or variance changes between sample groups with regard to the level of heteroscedasticity (Alexander, 1994). It is common, however when analyzing real data through implementing classic parametric tests to encounter a violation to the homogeneity of variance assumption. The reliance on classic tests which are not powerful enough to analyze heteroscedastic data can result in an inflation of Type I error, as well as failure to obtain a desirable level of statistical power (Seier, 2002).

It is essential when attempting to overcome the problem of violation of normality and homoscedastic assumption, to search for the most robust and powerful tests available. Hunter and May (1993) defined robustness of a statistical test as “the extent that violating its assumptions does not appreciable affect the probability of its Type I error” (p.386). The robustness of a statistical test is its sensitivity to departures from classical test assumptions. A statistical method is considered robust if the inferences are not seriously invalidated by the violation of such assumptions, for instance nonnormality and variance heterogeneity (Scheffe, 1959). Thus many applied researchers choose to use an alternative test procedure that is robust to assumption violations. A robust test is supposed to maintain the actual Type I error rate close to the nominal level and maintain actual statistical power close to theoretical power, even when the data does not conform to the assumptions of normal treatment populations and homogeneous population variances. However, due to variance heterogeneity and non-normality, classical tests can be misrepresented. In order to overcome the problem of assumption violation, numerous robust alternative tests were developed and used such as Yuen’s Test for trimmed means and the Alexander-Govern test (Tomarken & Serlin, 1986).

Welch-Aspin Test

Welch (1938) addressed variance heterogeneity by presenting the influence of group size by adjusting the degrees of freedom (df), which is the number of values that are free to vary, based on the total sample size (N) and the number of groups (J). The main idea of the Welch test uses the traditional t-statistic but without pooling the sample variances. The two tends to deal well with moderate skewness when variances are unequal, but does not perform well when extreme skewness or non-normality is combined with variance heterogeneity (Algina et al., 1994). In addition The two also had poor Type I error control when unequal variances and group sizes were combined with skewed distributions or dissimilar distribution shapes, particularly when skewness was unbalanced (Cribbie et al., 2011).

Welch's t-test, unlike Student's t-test, does not have the assumption of equal variance (however, both tests have the assumption of normality). When two groups have equal sample sizes and variances, Welch's tends to give the same result as Student's. However, when sample sizes and variances are unequal, Student's t-test is quite unreliable; Welch's tends perform better.

There is situation that both the independent samples t-test and Welch's test perform almost the same when sample sizes are equal and variances are equal. But when the sample sizes and variances are unequal, Welch test can be considered as a robust test to control Type I error rates comparing to the Student t-test (Derrick & White, 2016). Grimes and Federer (1982, p.10) state that, "In the case of comparing two sample means, the consensus in the literature seems to be the approval of Welch's approximate solution".

Wilcox (1996) concluded the discussion with a strong recommendation for the Yuen statistic (1974) as one of the best alternatives for heteroscedasticity:

> Confidence intervals based on Welch's procedure can be unsatisfactory when distributions have unequal skewness and unequal sample sizes and the sample sizes are not too large. An interesting feature of the Yuen test is that it maintains good control over the probability of a Type I error and probability coverage when computing confidence intervals in situations when the Welch's method is unsatisfactory (Wilcox 1994f). In fact, in terms of Type I errors and probability coverage Yuen's procedure seems to be the best among all procedures described in this chapter (p.139).

Yuen's Test for Trimmed Means

Yuen's test for trimmed means addresses the idea of computing the statistical technique to the trimmed mean based on removing a certain percentage of the observations, for instance, 20% from each tail of the distribution. (Kellermann et al., 2008). Consider the two independent samples layout when the problem of violation of the normality and variance homogeneity assumptions are present, typically due to skewness and outliers (Hayes & Cai, 2007). These problems can be remedied by the use of an alternative robust statistical test such as Yuen's test for trimmed means (Yuen, 1974). The trimmed mean is a measure of central tendency that allows the researcher to deal separately with a distribution's outliers. It is a mean computed without extreme observations (Vogt, 1993).

Yuen's test is described based on 20% trimming. When there is no trimming, it reduces to Welch's test. Under normality, Yuen's test yields about the same amount of power as methods based on means, but it helps guard against the deleterious effects of skewness and outliers. For the situation at hand, it will be seen that skewness plays a role when comparing means (Lix & Keselman, 1998).

Yuen's (1974) test helps to protect against the consequences of violating the normality assumption, and is designed to be robust to variance heterogeneity when testing for means equality for two independent groups (Lix, 1998). The idea of trimming is based on taking a fixed proportion of the largest and smallest observations from the data (Yuen, 1974). When implementing a trimming procedure consideration must be given regarding how much trimming should used, particularly when the distribution of the population is unknown. In order to obtain a small error, as well as to control the probability of a Type I error and avoid low power, 20% trimming was considered by Wilcox (1994) to be an optimal amount (Wilcox, 1996). However, Sawilowsky (2002) conducted a study using data set provided by Micceri (1986, 1989). The purpose of this study was to assess the index of location relative efficiency (LRE) of some robust methods of estimating location of a single sample. Two issues were raised in this study; (a) how much trim is considered more efficient in estimating location in real education and psychology data sets and (b) whether Huber's M-estimator is more efficient in estimating location in real education and psychology data sets with a 1.28,1.339,1.345, 1.4088, or 1.5 weighting constant. Sawilowsky (2002) concluded that the use of the Huber one-step is superior to trimming, whether the amount of trimming is small or large. However, the Huber method has yet to be successfully implemented in the inferential case, and therefore will not be considered further here.

According to Wilcox and Keselman (2003), the best way to deal with departures from normality and eliminate their effect is to use trimming when a distribution has extreme observations, trimming is considered to be an efficient method to remove such observations from each tail (Wilcox, 1998). Yuen (1974) proposed the trimmed means test for the independent two-sample case when data are not normal and population variances are not equal.

Alexander-Govern Test

The Alexander-Govern (1994) test was introduced to handle the problem of variance heterogeneity for normal data, but it is not robust to non-normal data. The power and robustness of the Alexander-Govern test against the presence of the violation of the variance homogeneity assumption compared with other tests such as the James test and the Welch test has been found to be a better alternative. The Alexander-Govern test, therefore, gives a good solution to the problem of variance heterogeneity and performs well in the control of Type I error for normal data (Myers, 1988).

A Monte Carlo study focusing on the effective control of Type I error rate and power was applied to the Alexander-Govern (1994) test was a simulation of normally distributed data for n = 2, 4, 6 treatment groups for both equal and unequal variances and sample sizes. The Type I error rate and power results were comparable to those of the James second-order test. Given their conclusions under normality, Alexander and Govern (1994) anticipated this test yields results similar to those of the James second-order under non-normal conditions.

Purpose of the Study

As mentioned above, the use of classic parametric tests for making inferences about the equality of means and measuring shifts of location has received great attention from many researchers in the educational and psychological sciences. Classic parametric tests are based on certain fundamental statistical assumptions that must be satisfied, for instance normality (i.e., data are drown from normal distribution) and homogeneity of variance (i.e., data has an equal variances). Violation of such assumptions is a common problem researchers encounter, particularly when analyzing real data. When such assumptions are violated, the effectiveness and efficiency of tests to control over the probability of a Type I error and maintain a relatively level of statistical power will be substantially affected.

Alternative modern and robust statistical tests such as Welch-Aspin test, Yuen test for trimmed means and the Alexander-Govern (1994) test can be used to overcome these assumption violations. The purpose of present study, then, is to research and explicate under non-normal and heteroscedastic conditions if the Welch-Aspin, Yuen, and Alexander-Govern tests is more robust with respect to Type I errors while maintaining a power advantage for detecting changes/differences in scale and location shifts. Through a Monte Carlo simulation, Type I error and power rates will be investigated, with varying study parameters, such as data sampled from various non-normal distributions, sample sizes, and alpha levels.

Limitations

The limitations of this study will be related to its input parameters, including various alpha levels, theoretical distributions, various magnitudes of shifts in location, and changes in scale. The alpha significance level will be limited to .01 and .05.

Definitions of Terms

Classic Tests**:** In statistical inference procedures (i.e., hypothesis tests and confidence intervals), classical tests are those that incorporate assumptions about population parameters.

Heterogeneous**:** The variability of a group becomes more and more different.

Heteroscedasticity**:** When the ratio of variances of two populations from which the data were sampled is not equal to one. It can occur when the variability of the treatment group becomes more and more different from the control group and causes the underlying assumptions of equal variances to become more and more violated (Sawilowsky, 2002).

Homogeneous**:** The variability of a group becomes more and more the same.

Monte Carlo Method: Repeated sampling from a population distribution to determine the long-run average of some parameter or characteristic. Sampling is usually done with replacement, meaning that a subset of scores is obtained, they are analyzed, the results are recorded, and the scores are returned to the reservoir of data values. On the next iteration, the values just examined have the same probability of being selected as values not yet examined (Sawilowsky & Fahoome, 2003).

Monte Carlo Simulations**:** The use of a computer program to simulate some aspect of reality to make determinations of the nature of reality or change in reality through repeated sampling via Monte Carlo methods (Sawilowsky & Fahoome, 2003).

Non-normality**:** Used to describe values of which the frequency distribution is markedly different from that of the normal probability distribution.

Parametric Tests: A parametric statistical test depends on a number of assumptions about the population from which the samples used in the test are drawn (Kerlinger & Lee, 2000).

Robustness: The robustness of a statistical method is its sensitivity to departures from classical test assumptions. It is the degree to which a statistical test maintains Types I and II error rates in light of assumption violations.

The Alexander-Govern Test**:** A test introduced by Alexander-Govern (1994) that uses the mean as a measure of its central tendency, and is also used in comparing two or more groups. This test gives a good control of Type I error rates and provides high power under variance heterogeneity for normal data, but it is not robust to non-normal data.

Trimmed Mean**:** A measure of central tendency that allows the researcher to deal separately with a distribution's outliers. It is a mean computed without the extreme observations (Vogt, 1993).

Type I Error**:** Also known as α. It is the experimental probability error of rejecting the null hypothesis when it is true.

Violation of Assumption: Statistical hypothesis tests generally make assumptions about the population(s) from which the data were sampled. Many normal-theory-based tests such as the *t*-test and ANOVA assume the data are sampled from one or more normal distributions. If test assumptions are violated, the test results may not be valid.

Welch (1938): Type statistics, which deal with the deleterious effects of variance heterogeneity on the usual ANOVA F test and Student's t test

Yuen Statistic (1974): A robust statistic used to increase power by increasing measures of location with standard errors that are relatively unaffected by heavy tails and outliers.

CHAPTER 2 REVIEW OF THE LETRUTURE

Classical statistical tests are used in many disciplines such as education and psychology (Ronchetti, 2006), even though they are based on assumptions (e.g., normality and homoscedasticity) that are difficult meet in order to produce accurate results. When those assumptions are not met, increased Type I errors and reduction of statistical power ensues (Stigler, 1977, Sawilowsky, 1990, Sawilowsky & Blair, 1992). In addition, Type I error rates and statistical power are substantially affected when the sample contains extreme observations or if the distribution sampled is heavy-tailed (Chen & Shapiro, 1995).

Parametric Versus Nonparametric Tests

Parametric Tests

Parametric tests are considered one of the best statistical procedures used for most applied research inquiry. These statistical techniques use probabilities to investigate hypotheses in which assumptions are made about the underlying distribution of the observed data in regards to the samples drawn from the population. Parametric tests are based on a group of assumptions which must be met such as; random assignment and random selection of the data, observations are independent of each other, variance is homogeneous, and the population is normally distributed. However, parametric tests for instance, the t-test, analysis of variance, and ordinary least squares multiple regressions can be more powerful and provide accurate information about the analyzed data when their underlying assumptions are not violated (Clinch & Keselman, 1982).

In addition, it is an accepted fact that the t test is considered to be one of the best statistical procedures in current use, especially under normal conditions. However, Sawilowsky and Blair (1992) noted that under assumption violations, for instance non-normality and variance heteroscedasticity, the test to be considered robust certain stipulations had to be met:

(a) Sample sizes had to be equal, or nearly so;
(b) Sample sizes were fairly large; and
(c) Tests were two-tailed rather than one-tailed (Sawilowsky & Blair, 1992, p.352)

Along with the *t* test (Sawilowsky & Blair, 1992), ANOVA is one of the most frequently used statistical tests to detect differences in means especially when its underlying assumptions are met (Glass, Peckman, & Sanders, 1972). However, under certain conditions such as violation of normality and homogeneity of variance assumptions and small sizes, the ability of ANOVA test procedure to control of Type I error rates as well maintain a satisfactory power level will be deteriorated (Kulinskaya, Staudte, & Gao, 2003).

Under certain conditions such as violation of normality and homogeneity assumptions, the performance of parametric testing becomes less powerful and less robust. However, as standard assumptions such as normality and homogeneity are violated, the ability of ANOVA test procedure to control of Type I error rates as well maintain a satisfactory power level will be deteriorated (Kulinskaya, Staudte, & Gao, 2003).)

Lindquist (1953) reported on a study conducted by one of his students on the robustness of the classic parameters estimator and *F* test compared to their nonparametric counterparts under non-normality. It was based on six different distributions (normal, leptokurtic, rectangular, moderately skewed, markedly skewed and j-shaped), claimed to be representative of those found in education and psychology. After comparing the resulting distributions from that study against the normal population for the *F* distribution, the findings of the experiment led Lindquist (1953) to conclude the following:

> The results of this study should be gratifying to anyone who has used or who contemplates using the *F* test of analysis of variance in experimental situations in which there is serious doubt about the underlying assumptions of normality and homogeneity of variance. Apparently, in the great majority of situations, one need be concerned hardly at all about lack of symmetry in the distribution of criterion measures, so long as the distribution is homogenous in both form and variance for the various treatment populations, and so long as it is neither markedly skewed nor markedly flat...In general, the *F* distribution seems so insensitive to the form of the distribution of criterion measure that it hardly seems worthwhile to apply any statistical test to the data to detect non-normality, even though such tests are available. Unless the departure from normality is so extreme that it may be easily detected by mere inspection of the data, the departure from normality will probably have no appreciable effect on the validity of the *F* test, and the probabilities read from the *F* table may be used as close approximations to the true probabilities. (p. 86).

The analysis of variance (ANOVA) is the most frequently used statistical test to detect differences in means (Glass, Peckman, & Sanders, 1972). However, when dealing with small sample sizes and not-normal distribution, the ability of ANOVA to control Type I error rates deteriorates. (Kulinskaya, Staudte, & Gao, 2003).

Nonparametric Tests

Statistical literature suggests that nonparametric tests, or distribution-free tests, are more powerful than parametric tests. Due to the latter not taking in to account the assumptions of a normal probability curve, nonparametric tests do not examine situations concerning parameters of population. Their statistics are less restrictive in terms of the assumptions compared to parametric techniques. Therefore, when the assumption of normality cannot be met, nonparametric, or distribution-free methods may be appropriate (Zimmerman, 2000).

There are three classifications of nonparametric tests: categorical, sign, and rank tests (Sawilowsky, 1990). The advantage of nonparametric tests is that they can maintain satisfactory Type I error properties even though normality assumption is not met (Sawilowsky & Fahoome, 2003). When testing shift in location, nonparametric tests are considered as robust and more powerful in the presence of non-normality.

Searching for solutions that can effectively address the Behrens-Fisher problem has long history within the literature. Sawilowsky (2002) mentioned that Yuen's Procedure (1974), based on trimmed means is considered to be a robust approximate solution even though many of the nonparametric tests were unsuccessful statistical methods. He also believed that an experimental treatment should possibly cause a change in scale, in other words, it is impractical or untrue in any experimental simulation to find that the treatment changed the variance while at the same time the means remained unchanged (Sawilowsky, 2002).

Although classic statistical tests are less powerful against the violation to their underlying assumptions, these outdated methods are still commonly used (Staudte, 1990; Sawilowsky & Blair, 1992; Sawilowsky, 2011), despite the availability of more robust and powerful alternative methods. SPSS, SAS, and the programming language R provide many robust alternatives to these less powerful classical procedures.

Prevalence of Variance Heterogeneity and Non-normality

Unequal population variances are particularly problematic for classical parametric and nonparametric tests, which lead to impairment of the test's statistical properties (Glass & Sanders, 1972). Unfortunately, this condition arises frequently when working with psychological and behavioral data (Golinski & Cribbie, 2009). Therefore, it is important to use the most powerful and robust test procedure possible as an alternative to the classic tests in the presence of such assumption violations (Yusof, Abdullah, Yahaya & Othman, 2011).

According to Sawilowsky and Fahoome (2003) the equal variance violation was considered of little consequence and incorrect especially considering the use of Monte Carlo research methods. Sawilowsky and Fahoome (2003) noted that for the ANOVA, F-test similar to the Students-t test:

> the literature on the behavior of the ANOVA F in the presence of violations of these three underlying assumptions is amazingly vast, considerable controversial, and only recently conclusive. Most of what is known regarding the operating characteristics of the Anova F test parallels work on the robustness of the t test. Most of the work is based on Monte Carlo studies. The violation of independence is a recipe for disaster in terms of Type I errors. There is no statistic that can overcome a true lack of independence, either within or between scores. Heteroscedasticity, or heterogeneous variances within or between groups, can also be quite debilitating in terms of type I errors (e.g., Randolph & Barcikowsky, 1989). This is especially so in no particular order, when (a) sample sizes are unequal, (b) cells with the smaller n's have the larger variances (c) accompanied by other violations of assumptions and (d) the degree of non-homogeneity increases (p. 292).

In addition, Type I error rates and statistical power are substantially affected when the sample contains extreme observations or if the distribution sampled is heavy-tailed (Chen & Shapiro, 1995). Sawilowsky and Blair (1992) indicated that when conditions such as equal variances and sample sizes, sample sizes are 25 or more per group and two-tailed tests are used, the *t* test can be relatively robust to violation of the normality. But when using one-tailed tests, the Type I error rate will be conservative and the power efficiency of the test will be reduced (Ramsey, 1992; Sawilowsky & Blair, 1992). Wilcox (1996) discussed some of the issues involved in violation of the equal variance assumption in relationship to the robustness of the t test:

> When distributions are normal and there are equal sample sizes, but the equal variance assumption is violated, Student's t-test provides fairly good control over the probability of Type I error if the sample sizes are not too small... However, when the sample sizes are unequal Student's-t can be unsatisfactory, even when sampling from a normal distribution... ...The situation is worse when the distributions are nonnormal (p.98).

According to Micceri (1989), it is rare that real world data are normally distributed in the educational and psychological literature. In fact, based on 440 large data sets (received from a survey of 2,000), none were normally distributed based on the Chi-Squared or Kolmogorov-Smirnov tests. Micceri's (1989) argument about the normality issue in real data sets was consistent with the skewed and asymmetrical distributions found previously by Bradley (1977), who stated when using the reaction time as a dependent variable the data are frequently skewed distribution shape (Bradley, 1977; see also Miller, 1988).

Bradley (1980), however, didn't agree that the word "large" adequately quantified the conditions of non-normality to ensure that the *t* test is a robust estimator. Bradley was arguing that it is common in real world situations to encounter many more non-normal distributions than those referenced in robustness studies.

Kesselman et al. (2004), Brown & Forsythe (1974), and Wilcox (1990) noted when using the two-sample *t* test to conduct certain statistical investigations, it will not be as stable or robust a test in the presence of non-normality and heteroscedasticity. Dixon (1960), Tukey and McLaughlin (1963) suggested a solution to this lack of stability and robustness was to use alternative procedures, such as trimming, to minimize the effects of long tailed distributions.

The *t*- test and analysis of variance (ANOVA) are the most common classical tests of group equality. However, due to variance heterogeneity and non-normality, those classical tests can be misrepresented. When assumptions such as normality and variance homogeneity are violated, many applied researchers tend to search for a robust alternative test that can be more powerful when dealing with the violation problem. The purpose of using a more robust test is its capability to maintain the actual Type I error rate close to the nominal level and maintain actual statistical power close to theoretical power. In order to overcome this problem, numerous robust alternative tests were developed and used such as Yuen's Test for trimmed means and

Alexander-Govern test (Tomarken & Serlin, 1986).

The Alexander-Govern (1994) Test

Non-normality has a major impact on the performance of a test in terms of controlling Type I error rates as well as its statistical power. This impact will also be exacerbated by the presence of unequal variances and sample size. Even with normal distribution, the violation of variance homogeneity assumption will result in empirical Type I error rates that deviate from the nominal level (Hsuing & Olejnik, 1996). In order to resolve the impact of violating the variance of homogeneity assumption, the Alexander-Govern Test (AG) is to be considered. The Alexander-Govern Test (AG) is a statistical procedure that used mean as its central tendency measure under normal distribution. It is important when using the AG test or any statistical tests to consider the underlying assumptions and be aware of any modification on the test is needed to ensure the use of any tests in any conditions (Abdullah & Othman, 2012).

The Alexander-Govern test is a test introduced by Alexander-Govern (1994) that uses mean as a measure of its central tendency and is also used in comparing two or more groups. This test gives a good control of Type I error rates, and provides high power under variance heterogeneity for a normal data but it is not robust to non-normal data. The test statistic for the Alexander-Govern test is obtained by using the procedures below:

Firstly, the mean of the test is calculated using:

$$\bar{X} = \frac{\sum x_i}{n} \qquad \textbf{(1)}$$

Where

X_{ij} denotes the observed ordered random samples and n_j represent the sample sizes of the observations. The mean is used as a measure of the central tendency in the Alexander-Govern (1994) method. After the mean is obtained, the estimate of the usual unbiased variance is obtained by using:

$$s^2 = \frac{\sum\left(x_i - \bar{x}\right)^2}{n-1} \qquad \textbf{(2)}$$

Where

Xj *is* used for estimating μ_j for the population *j*. The standard error of the mean is obtained for each of the groups, using:

$$S_{ej} = \left[\frac{s_j^2}{n_j}\right]^{1/2} \qquad \textbf{(3)}$$

The weight (w_j) for each of the independent groups is obtained using the formula:

$$w_j = \frac{1/S_{e\ j}^2}{\sum_j 1/S_{e\ j}^2} \qquad \textbf{(4)}$$

The null hypothesis testing for the Alexander-Govern (1994) technique, for the equality of the mean, under variance heterogeneity is defined as:

$$\begin{aligned} &H_o : \mu_1 = \ldots \mu_J \\ &H_A : \mu_1 \neq \ldots \mu_j, j = 1, \ldots, J \end{aligned} \qquad \textbf{(5)}$$

The alternative hypothesis negates the claim or statement made by the null hypothesis. The variance weighted estimate of the total mean for all the groups in the data distribution, is obtained using:

$$\hat{\mu} = \sum_{j=1}^{J} w_j \bar{X}_j \qquad \textbf{(6)}$$

Where

w_j is the weight for each of the group in the data distribution and Xj is the mean for each of the groups in the ordered sample. The *t* statistic for each of the groups is obtained using :

$$t_j = \frac{\bar{X}_j - \hat{\mu}}{S_{ej}} \qquad \textbf{(7)}$$

The *AG* formula is defined as:

$$\hat{\upsilon}_y = \frac{\left(d_1 + d_2\right)^2}{\frac{d_1^{\;2}}{h_{1-1}} + \frac{d_2^{\;2}}{h_{2-1}}} \qquad \textbf{(8)}$$

where

$$c = \left[a * 1og_e(1 + \frac{t_j^2}{v_j})\right]^{1/2} \qquad \textbf{(9)}$$

and where

$$v_j = n_j = 1, a = v_j - 0.5, b = 48a^2 \qquad \textbf{(10)}$$

The test statistic for the Alexander-Govern approach is expressed as:

$$A = \sum\nolimits_{j=1}^{J} z_j^2 \qquad \textbf{(11)}$$

The Alexander-Govern test was designed and introduced by Alexander-Govern in 1994. The test is considered to be a robust procedure and a better alternative to ANOVA F and T-test to handle the problem of variance heterogeneity (Alexander, 1994). Furthermore, the AG test was compared to other tests, for instance James test and Welch test and it performed remarkably well in controlling of Type I error and giving a high power rate due to its simplicity in calculation. However, the Alexander-Govern test is only recommended for a normal data and not for a non-normal data in the control of Type I error rates (Myers, 1998).

The performance of the Alexander Govern (AG) test, in terms of controlling Type I error rates, was evidently improved through the study of modifying the test. The study focused on modifying the AG test by replacing the mean with trimmed mean, regardless of the type of the distribution (Jamaluddin, 2014). The Alexander-Govern (1994) test was compared with the James and Welch tests and admitted by Schneider and Penfield (1997) to be a better alternative to ANOVA F and T-test. However, Myers (1998) specified that AG test is a good solution for solving the variance heterogeneity for normal data, but this test is not robust when dealing with non-normal data.

Testing the efficiency and reliability of the Alexander-Govern (*AG*) test and the Winsorized Modified One Step M-estimator in the Alexander-Govern (*AGWMOM*) test was done using real life data. In that simulation study, the homogeneity of variance assumption was tested for and Levene's test was implemented for the comprising groups. The results indicated that the *p*-value from the test of homogeneity of the variance is greater than 0.05, which means that there is no difference between the groups. However, the descriptive statistics showed that the *AGWMOM* test has a smaller standard error compared to the *AG* test. The result of the test statistic indicated that the *AGWMOM* test produced a *p*-value of 0.0000002869 that is considered to be significant compared to the *AG* test that produced a *p*-value of 0.0698, regarded as not significant, since its *p*-value is > 0.05. The authors of the study have concluded that the *AGWMOM* test is more efficient, reliable, and better at controlling Type I error rates than the *AG* test. (Ochuko et al., 2016).

According to Schneider and Penfield (1997) it is a well-known fact when using normal data, that the common mean is considered to be a good estimator. However, with the presence of outliers or when heavy tailed, the common mean will be extremely sensitive and can be observed when using Alexander-Govern test, especially when it uses the mean as its central tendency measures. The results of the study indicated that the AG test fails to control the Type I error rates as well given a high power when the data set is not normal.

Jamaluddin (2014) conducted a simulation study to investigate the performance of the Alexander-Govern (AG) test with respect to the rate of Type I error and power. Four variables; shape of distribution, sample size, level of variance heterogeneity and nature of pairings were manipulated. In this study, robust estimators, named the winsorized mean or adaptive winsorized mean were used and denoted with Alexander-Govern test as AGW and AGAW. The performance of the proposed tests was compared with the t-test and ANOVA. The results of the study indicated that the AGAW test performed best with 10% winsorization, while AGW test performed best with 5% winsorization. Under most conditions (74%), AGAW tests outperform AGW tests. Therefore, the winsorized mean and the adaptive winsorized mean can significantly improve the performance of the original Alexander-Govern test. In fact, these proposed procedures are beneficial to statistical practitioners in testing the equality of independent groups even under the influence of non-normality and variance heterogeneity (Jamaluddin, 2014)

Schneider and Penfield (1997) recommended using the Alexander and Govern approximation to be the best alternatives to the ANOVA F test when the variance of homogeneity assumption is violated. Thus, under most experimental conditions, the AG test was strongly recommended by most researchers and statisticians because of its simplicity of computation and its overall competence of controlling the Type I error rates while maintaining a desirable amount of power (Schneider & Penfield, 1997).

Myers (1998) conducted an empirical study to compare the performance of the Alexander and Govern (A) test to the James' second-order approximation (J) for controlling of both Type I and Type I1 errors. In that study, the author used simulated data from both symmetric and asymmetric distributions characterized by both non normality and heteroscedasticity. For normal data, the Alexander and Govern (A) test performed almost the same as James' test for controlling of both Type I and Type I1 errors, but it performed poorly in the presence of nonnormality. When using symmetric and asymmetric data, Alexander and Govern (A) imitated James' second-order approximation (J) in terms of alpha level and power rate. Both Alexander and Govern (A) and James' second-order approximation (J) are considered to be robust statistics particularly when data are symmetric but non-normal.

Yuen's (1974) Test for Trimmed Means.

Yuen (1974) initially suggested combining the use of trimmed means with Welch's (1951) statistical test.

The test statistic of Welch test is :

$$W = \frac{\left(\bar{X}_1 - \bar{X}_2\right) - \left(\mu_1 - \mu_2\right)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Welch test has the degrees of freedom of:

$$\hat{\upsilon} = \frac{\left(q_1 + q_2\right)^2}{\frac{q_1^2}{n_{1-1}} + \frac{q_2^2}{n_{2-1}}}$$

To obtain the Yuen's test statistic the following need to be calculated:

The test statistic of Yuen's test is

$$\mathrm{T}_y = \frac{\bar{\mathrm{X}}_t - \bar{Y}_t}{\sqrt{d_1 + d_2}}$$

The degrees of freedom are estimated to be

$$\hat{\upsilon}_y = \frac{\left(d_1 + d_2\right)^2}{\dfrac{d_1^{2}}{h_{1-1}} + \dfrac{d_2^{2}}{h_{2-1}}}$$

Yuen's study indicated that using trimmed means and Winsorized variances is a better solution in terms of controlling the rate of Type I errors and producing high power than using the usual mean and variances. However, no study has compared all of the previously enumerated tests employing trimmed means and Winsorized variances (Yuen & Dixon, 1973). Yuen's statistic (1974) was also suggested by Sawilowsky (2002) as a robust procedure (i.e., resilient to outliers) which adjusted the Student's t statistic (Student, 1908a) based on trimmed means and matching sample variances, as well as being useful as an adjustment for the Behrens-Fisher problem.

Under certain conditions in particular, nonnormal and variances are unequal, the use of trimmed means along with Welch's (1938) heteroscedastic statistic help to protect against the consequences of violating the normality assumption and is designed to be robust to variance heterogeneity, (Yuen, 1974). However when the trimming percentage is to zero, Yuen's method reduces to Welch's (1938) heteroscedastic method and can also be extended to dependent groups (Wilcox, 2002). Student's *t* test is not robust when its major assumptions are violated, such as normality and homogeneity of variances. This problem has led to the consideration of many robust alternatives, such as Yuen (1974). Yuen & Dixon (1973) proposed and evaluated the two-sample trimmed *t* robust test. Yuen's test has been examined extensively in recent years and found to have advantages when dealing with distributions that differ in skewness or when outliers are commonly encountered. The result of their study indicated that under exact normality there is small loss of power efficiency while a high power gain for long-tailed distributions.

In order to deal with low power issue that occurs due to non-normality, the usual mean can be replaced with robust measure of location such as trimmed mean. The use of trimmed means measures such as Yuen's test has an advantage over the usual mean due to its resistance to being affected by heavy tailed distributions (Rosenberger & Gasko, 1983). In addition to Yuen's test, Wilcox (1994*a*) reported that the result of Yuen's test on trimmed means was more satisfactory than the mean. Moreover, Algina, Oshima & Lin (1994) reported that the Yuen test had greater power than the Welch test when data were sampled from long-tailed distributions.

The testing of the equality of means across independent groups when assumptions are violated was commonly investigated via Monte Carlo simulation methods. (e.g., Lix & Keselman, 1998). Different alternative tests such as of Alexander and Govern, James, and Brown and Forsythe tests become liberal when the assumption of normality and homogeneity variances are violated. In addition, Keselman, Wilcox, Othman, and Fradette (2004) stated that in the presence of non-normality, using trimmed means is the best solution in order to achieve robustness.

Grissom (2000) asserted that it is common to expect heteroscedasticity and outliers in data, which can be considered effective factors on variance. He also indicated issues concerning robustness (i.e., control of Type I error rate) in the presence of heteroscedasticity and departures from normality, for which he suggested trimming as a way to stabilize variances.

An alternative for handling non-normality is to use Yuen's method (1974) with 20 percent trimmed means. In contrast to the mean, the 20 percent trimmed mean, which removes 20 percent of the largest and smallest observations, is able to eliminate the effect of extreme values and better capture the central tendency (Wilcox, 2003).

When comparing between Yuen’s and Welch's methods in terms of power, it is evident that Welch's test will be tremendously affected in the presence of non-normality (Oshima & Lin, 1994), whereas the use of Yuen’s test with 20% trimming is less affected. Moreover, Yuen’s test has advantages over Welch's and Student's t test when dealing Type I errors and probability coverage especially when the testing at the .05 or .01 level. Yuen’s test is considered a robust method in most applied work, particularly when based on 20% trimming. Under normality, this test yields about the same amount of power as tests based on means, but it helps guard against the deleterious effects of skewness and outliers.

Tukey and McLaughlin, (1963) Yuen, (1974) Hogg, (1974) Stigler, (1977) Cressie, (1980) Hill and Dixon, (1982) among others, recommended an alternative to the two sample *t* test under the condition of nonnormality. They proposed the use of trimmed means in order to deal with distributions that are being affected by outliers or heavy-tailed. Yuen’s (1974) study used a Monte Carlo simulation to investigate the effects of Welch’s approximate degrees of freedom *t* test and the trimmed *t* test. Her study focused on investigating the effect of those two tests on controlling Type I error inflation in the presence of unequal variance for both normal and long-tailed distributions. Based on the results, Yuen (1974) concluded that that deviation for Welch’s test was greater than that for the trimmed *t* test, meaning that the trimmed *t* had a greater probability of rejecting the null hypothesis when it was actually true.

Keselman et al. (2002) conducted a simulation study in order to compare measures of location across two groups. In that study, the authors compared three tests; the Welch test (1938), the Zhou et al. (1997) test, and the Yuen (1974) procedure, by using robust estimators of central tendency in order to investigate their power of controlling the Type I error rates under non-normality and variance heterogeneity conditions. The results of that study indicated that under a vast majority of cases likely to be encountered by applied researchers, and over the 162 conditions investigated, the Yuen (1974) procedure was the most reliable and robust test for controlling rate of Type I error while exhibiting many advantages (e.g., easy to compute and critical values from the standard *t* table can be used).

In another part of the study conducted by Yuen (1974) in order to prove that the use of trimmed means resulted in robust tests for mean equality, Yuen manipulated several variables included sample sizes (10 or 20), standard deviation ratios (0.25, 0.5, 2.0 and 4.0), trimming rate (*g*) (from 1 observation to .25observations), and a variety of distribution shapes. For each condition, ten thousand replications were generated. The results indicated obtaining a Type I error control for the trimmed means closer to the nominal alpha level. However, Yuen suggested using an adaptive trimming approach that ensured choosing the number of observations trimmed (*g*) should be based on the degree of leptokurtosis (Lix & Keselman, 1998).

According to literature, trimming is considered a valuable statistical procedure due to its efficiency in controlling Type I error rates and achieving high power (Wilcox & Keselman, 2003). In most previous studies, between 0 and .25 proved to be the ideal amount of trimming. Moreover, when distributions are skewed using 20% trimming will ensure accurate probability coverage of confident interval, especially when testing the mean differences (Wilcox, 1996). However, it can be difficult to determine the optimal amount of trimming when sample size is small.

Monte Carlo Methods Simulation

According to Sawilowsky and Fahoome (2003), “Monte Carlo refers to repeated sampling from a probability distribution to determine the long run average of some parameter or characteristic" (p. 46). It is important to distinguish a Monte Carlo method from simulations and Monte Carlo simulations. Simulations are fictitious depictions of reality, whereas a Monte Carlo method is a repetitive process which in this case can be used to solve a mathematical or statistical problem. Combining the two, a Monte Carlo simulation is "is the use of a computer program to simulate some aspect of reality, and making determinations of the nature of reality or change in reality through the repeated sampling via Monte Carlo methods" (p. 46).

Monte Carlo Simulations can be used to evaluate power and robustness, in respect to Type I error, of a statistical test under specified conditions. Monte Carlo simulations can be conducted by using computer compilers such as Fortran or other programming languages and platforms. Sawilowsky and Fahoome (2003) found that "Fortran is the shortest path to obtaining successful and useful results" (p. 46). Although the learning curve is longer than for R or SAS, the execution times are vastly superior for mathematical applications.

Lance (2011) mentioned that the Monte Carlo had "its modern roots in particle physics, where it was first used by scientists at the Los Alamos Laboratory to detect the location (or distance traveled) of neutrons (Metropolis, 1987) and was instrumental in research leading up to the development of the atomic bomb" (p.28). According to Sawilowsky and Fahoome (2003), simulation can be identified as a way of representing reality when there is a model that can be manipulated.

Robustness to Type I Errors

Robustness is the degree to which a statistical test maintains Type I and Type II error rates in light of testing assumption violations. Type I errors, generally referred to as false positives, can have a huge impact on output, more so than Type II errors (Sawilowsky & Fahoome, 2003). Monte Carlo simulations allow researchers to understand which tests work best under certain conditions as well as reduce the occurrence of Type I error. Bradley (1978) has concerns about the interaction of many conditions which led him to make a meaningful statement about the test violations:

> When the population assumptions are violated, the departures for p from α depend upon a complex interaction involving many factors: the size of α, the location of the rejection region, for the smallest sample, the absolute size of the sample and the absolute shape of the population form which it was drawn; and for each of the other samples, considered separately, the absolute and relative size of the sample, and the absolute shape, relative slope or relative variance of the population from which it was drawn (p. 146).

The proposed robustness magnitude limits defined by Bradley (1978) were between .5(α) and 1.5(α) for liberal limits, and between .9(α) and 1.1(α) for stringent limits. However, Lance (2011) has applied the proposed Bradley Limits in his study of robustness for the Winsorized T-Test. According to Lance (2011):

> The need for a study like this to apply Bradley's definitions of robustness for the Winsorized *t* exists as those for the regular *t* have existed (and continues so for tests conducted with real data distributions not examined by Micceri,1989) (pp.12, 13).

CHAPTER 3 METHODOLOGY

Most inferential statistical procedures are performed under certain strict assumptions. Violation to the underlying assumptions will result in a Type I error, as well as possibly the loss of statistical power. One solution is to select the most robust and powerful test from available competitors. In the context of two independent samples, therefore, the purpose of the study is to compare the robustness and comparative power of the Yuen's test, and the Alexander-Govern test when normality and homogeneity of variances assumptions are violated. The tests will be compared by using various distributions and sample sizes for a variety of pseudo-random number generator data sets.

Hypothesis Testing

Yuen's method is based on 20% trimming. When there is no trimming, it reduces to Welch's test. Under normality, Yuen's test yields about the same amount of power as methods based on means, but it helps guard against the deleterious effects of skewness and outliers. Welch-Aspin's test is an improved version of the Student t test and it is widely used as an alternative of Student's t test. It deals with the deleterious effects of variance heterogeneity on the usual ANOVA F test and Student's t test (Lix & Keselman, 1998) by adjustments in the estimation of the population variance, and via modification of the degrees of freedom. The Welch test is relatively robust to departures from variance heterogeneity. However, if sample size is small, the ability of Welch's test to limit the Type I error rate to the nominal level may decrease as variance heterogeneity increases or as the number of groups increases (Wilcox, 1988).

Wilcox (1996) recommended the Yuen statistic (1974) as one of the best alternatives when confronted with heteroscedasticity:

> Confidence intervals based on Welch's procedure can be unsatisfactory when distributions have unequal skewness and unequal sample sizes and the sample sizes are not too large. An interesting feature of the Yuen test is that it maintains good control over the probability of a Type I error and probability coverage when computing confidence intervals in situations when the Welch's method is unsatisfactory (Wilcox 1994f). In fact, in terms of Type I errors and probability coverage Yuen's procedure seems to be the best among all procedures described in this chapter (p.139).

The purpose of this study, therefore, is to compare the operating characteristics of the Welch-Aspin's, Yuen (1974) and Alexander-Govern (1994) test under assumption violations to determine which will is the most robust with respect to Type I and Type II errors (and associated power levels) when normality and homogeneity of variances assumptions are violated.

Monte Carlo

Monte Carlo simulation refers to "repeated sampling from a probability distribution to determine the long run average of some parameter of characteristic," (Sawilowsky & Fahoome, 2003, p. 46). Monte Carlo studies enable researchers to identify how sensitive the tests are to assumption violations. Monte Carlo method could help researchers to know the true null and false null hypotheses, and then the Type I error rates and statistical power rates can be obtained (Harwell, Rubinstein, Hayes & Olds, 1992).

According to Harwell (1990), a Monte Carlo simulation should be conducted in the following manner:

> In the typical MC study of a given statistical test the following process is repeated for a large number of samples: data are simulated which reflect a specific relationship among variables... The values of the statistical test provide information on its properties (e.g., the proportion of the "significant" values on the test). If the underlying assumption of the test were satisfied, exact statistical theory would guarantee that the test would have a specified type I error rate and would permit the probability of rejecting a false statistical hypothesis to be computed. Monte Carlo studies permit these characteristics to be examined when underlying assumptions are violated (p.4).

This study will be conducted via Monte Carlo simulation methods. The Monte Carlo Simulation will be utilized for the investigation of the comparative power and robustness of Yuen's (1974) test and Alexander-Govern (1994) test under non-normal distributional conditions, heterogeneous using various sample sizes and distributions. Monte Carlo simulations are computer experiments involving random sampling from known probability distributions to study properties of statistical methods (Mooney, 1997).

Monte Carlo Simulation in R Programming Language.

A Monte Carlo program will be written using the computer programming language called *R*. URL http://www.R-project.org/, packages WRS2 and one way tests.

Sample Size and Nominal Alpha

According to Cribbie (2004):

> "One of the primary motivations for utilizing tests of equivalence is that as sample sizes increases, the probability of finding even trivial mean differences statistically significant becomes larger" (p.5).

The Monte Carlo simulation will be conducted on equal and unequal samples of size combinations (n1, n2) = (30,30), (20, 40), (60, 60), (40,80) (90,90), and (60,120). Sample sizes were selected based on their representation of real world data sets often used in the behavioral and social sciences. Nominal alpha levels will be set at .01 and .05.

The effect size for treatment groups will be manipulated at different levels except the baseline group which contains 0 effect size to simulate no treatment effect. The shift treatment effects will be applied to the treatment groups at the level of, 0.01σ,0.2σ, 0.5σ, 0.8σ, 1.2σ and 2σ. The level of heterogeneous variances will be set at (1:1), (1:4) and (1:16). in each iteration of the study. The number of iterations will be 20,000, because it will result in a small standard error. This study will be conducted by using observations of different sample sizes sampled with replacement from a variety theoretical distributions generated by pseudo-random number generator. The distributions generated by pseudo-random number generator are the theoretical distributions include the normal, uniform, exponential, *t* (df = 2), and Chi-squared (df = 3).

Robustness With Respect to Type I Error

The robustness of each statistical test with respect to Type I error will be addressed via the simulation. According to Sawilowsky and Fahoome (2003), a Type I error is a chance occurrence which happens when the null hypothesis is true but the chance fluctuation rejects the null hypothesis at the level of nominal alpha. The number of significant results divided by the numbers of replications is Type I error rate. The Bradley (1978) liberal criterion test will be used to assess the robustness with respect to Type I error. According to Bradley's (1978) liberal criterion of robustness, a test can be considered robust if its empirical rate of Type I error, α, is within the interval $0.5\alpha < \alpha < 1.5\alpha$. Thus, if the nominal level is $\alpha = 0.05$, the empirical Type I error rate should be within the interval $.025 < \alpha < .075$. Similarly, if the nominal level is $\alpha = 0.01$, the empirical Type I error rate should be within interval $.005 < \alpha < .015$. Type I error rates above the upper robustness limit are considered liberal.

Presentation of Results

Results will be reported using tables of rejection rates to depict the Type I error rates under the truth of the null hypothesis, as well as the relative power of each statistical method under non-normal and heteroscedastic conditions. For each condition, a graph will illustrate the power curve of the two statistics being explored.

The following illustration demonstrates the usage of the tests; Welch-Aspin test, Yuen's (1974) test for trimmed means, and the Alexander-Govern (1994) test for testing the equality of the two independent groups mean. Minitab 17 computer programming was used to generate pseudo random numbers drawn from a normal population with mean = 0 and standard deviation = 1. The seed was set at 123457 and 123458 for data sets X and Y, respectively. In Table 1 two independent samples x and y in which each sample contains of 20 random numbers. The random numbers have been sorted and that is showing in Table 2.

Table 1. Pseudo Random Numbers for x (seed = 123457) and y (seed = 123458).

X	Y
0.616123	0.260131
-0.54148	0.289278
0.422561	1.33964
1.642958	0.877618
0.857226	0.518254
0.839956	0.683003
0.709968	-0.91914
0.168052	-0.72253
-0.07152	1.172475
0.981442	-0.75977
0.051183	-0.01824
0.929159	1.576766
-1.77559	-1.47973
0.458555	-1.2722
0.999554	-0.09637
0.148695	-0.08969
-0.18808	-0.3601
-1.4113	-0.80916
-0.69457	-0.33273
0.04696	-0.28859

Table 2. Sorted X and Y values.

X	Y
-1.77559	-1.47973
-1.4113	-1.2722
-0.69457	-0.91914
-0.54148	-0.80916
-0.18808	-0.75977
-0.07152	-0.72253
0.04696	-0.3601
0.051183	-0.33273
0.148695	-0.28859
0.168052	-0.09637
0.422561	-0.08969
0.458555	-0.01824
0.616123	0.260131
0.709968	0.289278
0.839956	0.518254
0.857226	0.683003
0.929159	0.877618
0.981442	1.172475
0.999554	1.33964
1.642958	1.576766

Because Yuen’s test for trimmed mean is on of the three compared tests for this example, it is important to apply two-side 20% Trim of X and Y values and that indicated in Table 3.

Table 3. Two-side 20% Trim of X and Y values.

X	Y
-0.18808	-0.75977
-0.07152	-0.72253
0.04696	-0.3601
0.051183	-0.33273
0.148695	-0.28859
0.168052	-0.09637
0.422561	-0.08969
0.458555	-0.01824
0.616123	0.260131
0.709968	0.289278
0.839956	0.518254
0.857226	0.683003

In the current example the independent two-sample t.test was performed using the Minitab 17 for the three tests; Welch's test, Yuen's test for 20% trimmed mean, and the Alexander-Govern test. Figures1, 2, and 3 show the Minitab 17 output of the two-sample t.test of Welch-Aspin test, Yuen's test, and the Alexander-Govern test.

```
 PRINT TEST STATISTIC
K25    0.739622

PRINT DEGREES OF FREEDOM
K51    1.00000
K26    39.9758

PRINT CRITICAL VALUE
K27    4.08490

PRINT SIGNIFICANCE LEVEL
K30    0.394910
```

Figure 1. Minitab 17 Output for Welch-Aspin Test for Data in Table 1.

```
MTB > Execute "C:\...\YUEN.MTB" 1.
Executing from file: C:\...\YUEN.MTB
Executing from file: trim.mtb

 THE TRIMMED MEAN IS
K10    0.338307

 ESTIMATE OF ASYMPTOTIC STANDARD ERROR
K13    0.162683

 APPROXIMATE 95% CONFIDENCE LIMITS
K16    -0.0197566
K17    0.696370

Executing from file: trim.mtb

 THE TRIMMED MEAN IS
K10    -0.0764473

 ESTIMATE OF ASYMPTOTIC STANDARD ERROR
K13    0.216753

 APPROXIMATE 95% CONFIDENCE LIMITS
K16    -0.553517
K17    0.400622

 PRINT DIFFERENCE IN THE TRIMMED MEANS
K33    0.414754

 PRINT YUEN'S ESTIMATE OF THE STANDARD ERROR OF THE DIFFERENCE
K45    0.275896

 PRINT .95 CONFIDENCE INTERVAL FOR DIFFERENCE BETWEEN TRIMMED MEANS
K41    -0.160018
K42    0.989526

 PRINT ESTIMATED DEGREES OF FREEDOM
K39    20.4077

 PRINT ABSOLUTE VALUE OF YUEN'S TEST STATISTIC
K45    1.50330

 PRINT SIGNIFICANCE LEVEL (TWO-SIDED TEST)
K46    0.148080
```

Figure 2. Minitab 17 Output of Yuen’s 20% Trim Test for Data in Table 1.

```
MTB > Execute "C:\...\AG.MTB" 1.
Executing from file: C:\...\AG.MTB

 VALUE OF TEST STATISTIC IS
K3    0.713526

SIGNIFIANCE LEVEL IS
 K6    0.398276
```

Figure 3. Minitab 17 Output for Alexander-Govern Test for Data inTable 1.

Table 4. Summary of Results of Competitor Tests.

Test	p value
Welch-Aspin	0.39491
Yuen (20%)	0.14808
Alexander-Govern	0.398276

After obtaining the test significance *(P. value)* of each test for testing the mean equality of the two independent groups. In Table 4, each test has a p value as the following; Welch's test (0.39491), (0.14808) for Yuen's 20% trimmed mean test, and (0.398276) for the Alexander-Govern test. Based on the p-value of the three tests in Table 4, all of them are greater than the significance level .05. Therefore, the same decision is to fail to reject the null hypothesis, because there is no evidence to conclude that the difference between the two independent group means is statistically significant, as expected with pseudo-random data. Note, however, the magnitude of the nonsignificant results differ among the three tests and it can be concluded that Yuen's test might be more powerful test comparing to the other two tests.

CHAPTER 4 RESULS

The tables presented below are the results of a Monte Carlo study that was conducted with twenty thousand iterations via R programming language on a MacBook Pro laptop computer with Intel Core i5-1333M CPU at 2.4 GHz. The calculation amounts in this research are huge. It takes around 34 hours to run the whole simulation study.

In this research, a total of 9,072 pieces of data produced is presented in the following 216 tables. The tables are sectioned by the 4 distributions under the study, each containing 54 tables. Under each distribution, the tables are organized based on their sample sizes, effect sizes, Alpha levels and scales

Each table contains the total rejection rates of the three tests at two alpha levels of 0.05, 0.01. The sample sizes are presented in the order (n1, n2) = (30,30), (20, 40), (60, 60), (40,80) (90,90), and (60,120) The effect sizes are presented in the order of 0.0σ, 0.01, 0.2σ, 0.5σ, 0.8σ, 1.2σ and 2.0σ. The scale effects are presented in the order of 1:1, 1:4 and 1:16. Furthermore, trimming computation of .0%, 0.1% and 0.2% was applied in order to observe changes on the performance of Yuen test.

Table 5 to Table 58 contains the Type I error and power rates of the three tests under the normal distribution. Table 59 to Table 113 contains the Type I error and power rates of the three tests under the uniform distribution. Table 114 to Table 168 contains the Type I error and power rates of the three tests under the exponential distribution. Table 169 to Table 220 contains the Type I error and power rates of the three tests under the chi-squared distribution.

Table 5. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=0	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0482	0.04845	0.1129	0.47585	0.8623	0.99575	*
Alexander-Govern	0.0474	0.04755	0.1112	0.4722	0.8605	0.99565	*
Yuen	0.0474	0.04755	0.1112	0.4722	0.8605	0.99565	*
	α = .01						
Welch-Aspin	0.0093	0.0091	0.0333	0.238	0.66815	0.97515	*
Alexander-Govern	0.0090	0.0087	0.03255	0.23435	0.6641	0.9741	*
Yuen	0.0090	0.0087	0.03255	0.23435	0.6641	0.9741	*

Note: c = fraction or multiple of the population standard deviation.

Table 6. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=0	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0514	0.0517	0.1063	0.43045	0.8156	0.98865	*
Alexander-Govern	0.0505	0.05075	0.10485	0.4277	0.81405	0.98835	*
Yuen	0.0505	0.05075	0.10485	0.4277	0.81405	0.98835	*
	α = .01						
Welch-Aspin	0.011	0.011	0.0317	0.20145	0.587	0.9456	*
Alexander-Govern	0.0108	0.01065	0.03125	0.1989	0.5839	0.94505	*
Yuen	0.0108	0.01065	0.03125	0.1989	0.5839	0.94505	*

Note: c = fraction or multiple of the population standard deviation.

Table 7. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=0	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0491	0.0507	0.1931	0.7789	0.99195	*	*
Alexander-Govern	0.0488	0.0505	0.1921	0.77745	0.99185	*	*
Yuen	0.0488	0.0505	0.1921	0.77745	0.99185	*	*
	α = .01						
Welch-Aspin	0.01055	0.01045	0.06865	0.55195	0.96175	0.9998	*
Alexander-Govern	0.0104	0.0103	0.0679	0.5501	0.9613	0.9998	*
Yuen	0.0104	0.0103	0.0679	0.5501	0.9613	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 8. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=0	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0481	0.04805	0.17385	0.72535	0.98465	*	*
Alexander-Govern	0.0476	0.04745	0.17295	0.7237	0.98445	*	*
Yuen	0.0476	0.04745	0.17295	0.7237	0.98445	*	*
	α = .01						
Welch-Aspin	0.0083	0.00805	0.05655	0.4792	0.9307	0.9998	*
Alexander-Govern	0.0082	0.00805	0.056	0.4775	0.92965	0.9998	*
Yuen	0.0082	0.00805	0.056	0.4775	0.92965	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 9. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=0	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0501	0.04995	0.26285	0.9147	0.99985	*	*
Alexander-Govern	0.04975	0.04975	0.2623	0.91415	0.99985	*	*
Yuen	0.04975	0.04975	0.2623	0.91415	0.99985	*	*
	α = .01						
Welch-Aspin	0.00955	0.00995	0.1036	0.7743	0.99635	*	*
Alexander-Govern	0.0094	0.00995	0.1028	0.77295	0.9963	*	*
Yuen	0.0094	0.00995	0.1028	0.77295	0.9963	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 10. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=0	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0502	0.0515	0.23965	0.9147	0.999	*	*
Alexander-Govern	0.05005	0.05095	0.2389	0.91415	0.999	*	*
Yuen	0.05005	0.05095	0.2389	0.91415	0.999	*	*
	α = .01						
Welch-Aspin	0.0097	0.0097	0.093	0.7743	0.99635	*	*
Alexander-Govern	0.0097	0.00965	0.0925	0.77295	0.9963	*	*
Yuen	0.0097	0.00965	0.0925	0.77295	0.9963	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 11. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = .1 Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04815	0.04845	0.1063	0.47585	0.8623	0.99575	*
Alexander-Govern	0.04735	0.04755	0.10485	0.4722	0.8605	0.99565	*
Yuen	0.04735	0.04755	0.10485	0.4722	0.8605	0.99565	*
	α = .01						
Welch-Aspin	0.00925	0.0091	0.0317	0.238	0.66815	0.97515	*
Alexander-Govern	0.0090	0.0087	0.03125	0.23435	0.6641	0.9741	*
Yuen	0.0090	0.0087	0.03125	0.23435	0.6641	0.9741	*

Note: c = fraction or multiple of the population standard deviation.

Table 12. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0514	0.0517	0.1063	0.43045	0.8156	0.98865	*
Alexander-Govern	0.0505	0.05075	0.10485	0.4277	0.8156	0.98835	*
Yuen	0.0505	0.05075	0.10485	0.4277	0.8156	0.98835	*
	α = .01						
Welch-Aspin	0.011	0.011	0.0317	0.20145	0.587	0.9456	*
Alexander-Govern	0.01075	0.01065	0.03125	0.1989	0.5839	0.94505	*
Yuen	0.01075	0.01065	0.03125	0.1989	0.5839	0.94505	*

Note: c = fraction or multiple of the population standard deviation.

Table 13. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0491	0.0507	0.1931	0.7789	0.99195	*	*
Alexander-Govern	0.0488	0.0505	0.1921	0.77745	0.99185	*	*
Yuen	0.0488	0.0505	0.1921	0.77745	0.99185	*	*
	α = .01						
Welch-Aspin	0.01055	0.01045	0.06865	0.55195	0.96175	0.9998	*
Alexander-Govern	0.01035	0.0103	0.0679	0.5501	0.9613	0.9998	*
Yuen	0.01035	0.0103	0.0679	0.5501	0.9613	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 14. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0481	0.04805	0.17385	0.72535	0.98465	*	*
Alexander-Govern	0.0476	0.04745	0.17295	0.7237	0.98445	*	*
Yuen	0.0476	0.04745	0.17295	0.7237	0.98445	*	*
	α = .01						
Welch-Aspin	0.0083	0.00805	0.05655	0.4792	0.9307	0.9998	*
Alexander-Govern	0.00815	0.00805	0.056	0.4775	0.92965	0.9998	*
Yuen	0.00815	0.00805	0.056	0.4775	0.92965	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 15. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0501	0.04995	0.26285	0.9147	0.99985	*	*
Alexander-Govern	0.04975	0.04975	0.2623	0.91415	0.99985	*	*
Yuen	0.04975	0.04975	0.2623	0.91415	0.99985	*	*
	α = .01						
Welch-Aspin	0.00955	0.00995	0.1036	0.7743	0.99635	*	*
Alexander-Govern	0.0094	0.00995	0.1028	0.77295	0.9963	*	*
Yuen	0.0094	0.00995	0.1028	0.77295	0.9963	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 16. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0502	0.0515	0.23965	0.87975	0.999	*	*
Alexander-Govern	0.05005	0.05095	0.2389	0.8791	0.999	*	*
Yuen	0.05005	0.05095	0.2389	0.8791	0.999	*	*
	α = .01						
Welch-Aspin	0.0097	0.0097	0.093	0.70745	0.99205	*	*
Alexander-Govern	0.00965	0.00965	0.0925	0.7065	0.99195	*	*
Yuen	0.00965	0.00965	0.0925	0.7065	0.99195	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 17. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = .2 Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04815	0.04845	0.1063	0.47585	0.8623	0.99575	*
Alexander-Govern	0.04735	0.04755	0.10485	0.4722	0.8605	0.99565	*
Yuen	0.04735	0.04755	0.10485	0.4722	0.8605	0.99565	*
	α = .01						
Welch-Aspin	0.00925	0.0091	0.0317	0.238	0.66815	0.97515	*
Alexander-Govern	0.0090	0.0087	0.03125	0.23435	0.6641	0.9741	*
Yuen	0.0090	0.0087	0.03125	0.23435	0.6641	0.9741	*

Note: c = fraction or multiple of the population standard deviation.

Table 18. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0514	0.0517	0.1063	0.43045	0.8156	0.98865	*
Alexander-Govern	0.0505	0.05075	0.10485	0.4277	0.8156	0.98835	*
Yuen	0.0505	0.05075	0.10485	0.4277	0.8156	0.98835	*
	α = .01						
Welch-Aspin	0.011	0.011	0.0317	0.20145	0.587	0.9456	*
Alexander-Govern	0.01075	0.01065	0.03125	0.1989	0.5839	0.94505	*
Yuen	0.01075	0.01065	0.03125	0.1989	0.5839	0.94505	*

Note: c = fraction or multiple of the population standard deviation.

Table 19. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0491	0.0507	0.1931	0.7789	0.99195	*	*
Alexander-Govern	0.0488	0.0505	0.1921	0.77745	0.99185	*	*
Yuen	0.0488	0.0505	0.1921	0.77745	0.99185	*	*
	α = .01						
Welch-Aspin	0.01055	0.01045	0.06865	0.55195	0.96175	0.9998	*
Alexander-Govern	0.01035	0.0103	0.0679	0.5501	0.9613	0.9998	*
Yuen	0.01035	0.0103	0.0679	0.5501	0.9613	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 20. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0481	0.04805	0.17385	0.72535	0.98465	*	*
Alexander-Govern	0.0476	0.04745	0.17295	0.7237	0.98445	*	*
Yuen	0.0476	0.04745	0.17295	0.7237	0.98445	*	*
	α = .01						
Welch-Aspin	0.0083	0.00805	0.05655	0.4792	0.9307	0.9998	*
Alexander-Govern	0.00815	0.00805	0.056	0.4775	0.92965	0.9998	*
Yuen	0.00815	0.00805	0.056	0.4775	0.92965	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 21. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0501	0.04995	0.26285	0.9147	0.99985	*	*
Alexander-Govern	0.04975	0.04975	0.2623	0.91415	0.99985	*	*
Yuen	0.04975	0.04975	0.2623	0.91415	0.99985	*	*
	α = .01						
Welch-Aspin	0.00955	0.00995	0.1036	0.7743	0.99635	*	*
Alexander-Govern	0.0094	0.00995	0.1028	0.77295	0.9963	*	*
Yuen	0.0094	0.00995	0.1028	0.77295	0.9963	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 22. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:1			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0502	0.0515	0.23965	0.87975	0.999	*	*
Alexander-Govern	0.05005	0.05095	0.2389	0.8791	0.999	*	*
Yuen	0.05005	0.05095	0.2389	0.8791	0.999	*	*
	α = .01						
Welch-Aspin	0.0097	0.0097	0.093	0.70745	0.99205	*	*
Alexander-Govern	0.00965	0.00965	0.0925	0.7065	0.99195	*	*
Yuen	0.00965	0.00965	0.0925	0.7065	0.99195	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 23. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=0	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04715	0.04705	0.07315	0.21885	0.48185	0.81815	0.99755
Alexander-Govern	0.0468	0.0466	0.07265	0.217	0.47955	0.8167	0.99745
Yuen	0.0468	0.0466	0.07265	0.217	0.47955	0.8167	0.99745
	α = .01						
Welch-Aspin	0.0095	0.00935	0.0171	0.0779	0.2391	0.59685	0.985
Alexander-Govern	0.00935	0.0092	0.0167	0.0766	0.2369	0.59455	0.9848
Yuen	0.00935	0.0092	0.0167	0.0766	0.2369	0.59455	0.9848

Note: c = fraction or multiple of the population standard deviation.

Table 24. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=0	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.052	0.0524	0.07005	0.1716	0.36745	0.68215	0.97975
Alexander-Govern	0.05155	0.0521	0.0696	0.17085	0.3658	0.6811	0.9797
Yuen	0.05155	0.0521	0.0696	0.17085	0.3658	0.6811	0.9797
	α = .01						
Welch-Aspin	0.01055	0.01065	0.01715	0.0572	0.1577	0.41525	0.9103
Alexander-Govern	0.0105	0.0106	0.0171	0.05695	0.1575	0.41485	0.91015
Yuen	0.0105	0.0106	0.0171	0.05695	0.1575	0.41485	0.91015

Note: c = fraction or multiple of the population standard deviation.

Table 25. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=0	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0497	0.05045	0.1069	0.4035	0.78425	0.9843	*
Alexander-Govern	0.0495	0.05005	0.1062	0.4026	0.78315	0.98415	*
Yuen	0.0495	0.05005	0.1062	0.4026	0.78315	0.98415	*
	α = .01						
Welch-Aspin	0.01025	0.0106	0.0303	0.19095	0.55495	0.93465	*
Alexander-Govern	0.0101	0.0105	0.03015	0.1904	0.55415	0.9342	*
Yuen	0.0101	0.0105	0.03015	0.1904	0.55415	0.9342	*

Note: c = fraction or multiple of the population standard deviation.

Table 26. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=0	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0483	0.0493	0.0874	0.30965	0.64545	0.9399	*
Alexander-Govern	0.0481	0.04915	0.08715	0.3091	0.64505	0.93975	*
Yuen	0.0481	0.04915	0.08715	0.3091	0.64505	0.93975	*
	α = .01						
Welch-Aspin	0.00825	0.0084	0.02405	0.1275	0.38995	0.81115	0.99945
Alexander-Govern	0.0082	0.0084	0.02395	0.12725	0.38955	0.81075	0.99945
Yuen	0.0082	0.0084	0.02395	0.12725	0.38955	0.81075	0.99945

Note: c = fraction or multiple of the population standard deviation.

Table 27. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=0	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0504	0.05065	0.133	0.55845	0.9198	0.99945	*
Alexander-Govern	0.0502	0.0505	0.1327	0.5573	0.91945	0.99945	*
Yuen	0.0502	0.0505	0.1327	0.5573	0.91945	0.99945	*
	α = .01						
Welch-Aspin	0.0094	0.00965	0.0401	0.3121	0.782	0.99285	*
Alexander-Govern	0.00925	0.0096	0.0398	0.31115	0.7814	0.9928	*
Yuen	0.00925	0.0096	0.0398	0.31115	0.7814	0.9928	*

Note: c = fraction or multiple of the population standard deviation

Table 28. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=0	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0511	0.0515	0.1118	0.43995	0.8209	0.9912	*
Alexander-Govern	0.05105	0.0515	0.1117	0.43955	0.82065	0.9911	*
Yuen	0.05105	0.0515	0.1117	0.43955	0.82065	0.9911	*
	α = .01						
Welch-Aspin	0.00945	0.0097	0.03215	0.2137	0.61285	0.9551	*
Alexander-Govern	0.0094	0.0096	0.03215	0.2134	0.61235	0.955	*
Yuen	0.0094	0.0096	0.03215	0.2134	0.61235	0.955	*

Note: c = fraction or multiple of the population standard deviation.

Table 29. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04715	0.04705	0.07315	0.21885	0.48185	0.81815	0.99755
Alexander-Govern	0.0468	0.0466	0.07265	0.217	0.47955	0.8167	0.99745
Yuen	0.0468	0.0466	0.07265	0.217	0.47955	0.8167	0.99745
	α = .01						
Welch-Aspin	0.0095	0.00935	0.0171	0.0779	0.2391	0.59685	0.985
Alexander-Govern	0.00935	0.0092	0.0167	0.0766	0.2369	0.59455	0.9848
Yuen	0.00935	0.0092	0.0167	0.0766	0.2369	0.59455	0.9848

Note: c = fraction or multiple of the population standard deviation.

Table 30. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.052	0.0524	0.07005	0.1716	0.36745	0.68215	0.97975
Alexander-Govern	0.05155	0.0521	0.0696	0.17085	0.3658	0.6811	0.9797
Yuen	0.05155	0.0521	0.0696	0.17085	0.3658	0.6811	0.9797
	α = .01						
Welch-Aspin	0.01055	0.01065	0.01715	0.0572	0.1577	0.41525	0.9103
Alexander-Govern	0.0105	0.0106	0.0171	0.05695	0.1575	0.41485	0.91015
Yuen	0.0105	0.0106	0.0171	0.05695	0.1575	0.41485	0.91015

Note: c = fraction or multiple of the population standard deviation.

Table 31. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0497	0.05045	0.1069	0.4035	0.78425	0.9843	*
Alexander-Govern	0.0495	0.05005	0.1062	0.4026	0.78315	0.98415	*
Yuen	0.0495	0.05005	0.1062	0.4026	0.78315	0.98415	*
	α = .01						
Welch-Aspin	0.01025	0.0106	0.0303	0.19095	0.55495	0.93465	*
Alexander-Govern	0.0101	0.0105	0.03015	0.1904	0.55415	0.9342	*
Yuen	0.0101	0.0105	0.03015	0.1904	0.55415	0.9342	*

Note: c = fraction or multiple of the population standard deviation.

Table 32. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0483	0.0493	0.0874	0.30965	0.64545	0.9399	*
Alexander-Govern	0.0481	0.04915	0.08715	0.3091	0.64505	0.93975	*
Yuen	0.0481	0.04915	0.08715	0.3091	0.64505	0.93975	*
	α = .01						
Welch-Aspin	0.00825	0.0084	0.02405	0.1275	0.38995	0.81115	0.99945
Alexander-Govern	0.0082	0.0084	0.02395	0.12725	0.38955	0.81075	0.99945
Yuen	0.0082	0.0084	0.02395	0.12725	0.38955	0.81075	0.99945

Note: c = fraction or multiple of the population standard deviation.

Table 33. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0504	0.05065	0.133	0.55845	0.9198	0.99945	*
Alexander-Govern	0.0502	0.0505	0.1327	0.5573	0.91945	0.99945	*
Yuen	0.0502	0.0505	0.1327	0.5573	0.91945	0.99945	*
	α = .01						
Welch-Aspin	0.0094	0.00965	0.0401	0.3121	0.782	0.99285	*
Alexander-Govern	0.00925	0.0096	0.0398	0.31115	0.7814	0.9928	*
Yuen	0.00925	0.0096	0.0398	0.31115	0.7814	0.9928	*

Note: c = fraction or multiple of the population standard deviation

Table 34. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:1, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0511	0.0515	0.1118	0.43995	0.8209	0.9912	*
Alexander-Govern	0.05105	0.0515	0.1117	0.43955	0.82065	0.9911	*
Yuen	0.05105	0.0515	0.1117	0.43955	0.82065	0.9911	*
	α = .01						
Welch-Aspin	0.00945	0.0097	0.03215	0.2137	0.61285	0.9551	*
Alexander-Govern	0.0094	0.0096	0.03215	0.2134	0.61235	0.955	*
Yuen	0.0094	0.0096	0.03215	0.2134	0.61235	0.955	*

Note: c = fraction or multiple of the population standard deviation.

Table 35. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04715	0.04705	0.07315	0.21885	0.48185	0.81815	0.99755
Alexander-Govern	0.0468	0.0466	0.07265	0.217	0.47955	0.8167	0.99745
Yuen	0.0468	0.0466	0.07265	0.217	0.47955	0.8167	0.99745
	α = .01						
Welch-Aspin	0.0095	0.00935	0.0171	0.0779	0.2391	0.59685	0.985
Alexander-Govern	0.00935	0.0092	0.0167	0.0766	0.2369	0.59455	0.9848
Yuen	0.00935	0.0092	0.0167	0.0766	0.2369	0.59455	0.9848

Note: c = fraction or multiple of the population standard deviation.

Table 36. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.052	0.0524	0.07005	0.1716	0.36745	0.68215	0.97975
Alexander-Govern	0.05155	0.0521	0.0696	0.17085	0.3658	0.6811	0.9797
Yuen	0.05155	0.0521	0.0696	0.17085	0.3658	0.6811	0.9797
	α = .01						
Welch-Aspin	0.01055	0.01065	0.01715	0.0572	0.1577	0.41525	0.9103
Alexander-Govern	0.0105	0.0106	0.0171	0.05695	0.1575	0.41485	0.91015
Yuen	0.0105	0.0106	0.0171	0.05695	0.1575	0.41485	0.91015

Note: c = fraction or multiple of the population standard deviation.

Table 37. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0497	0.05045	0.1069	0.4035	0.78425	0.9843	*
Alexander-Govern	0.0495	0.05005	0.1062	0.4026	0.78315	0.98415	*
Yuen	0.0495	0.05005	0.1062	0.4026	0.78315	0.98415	*
	α = .01						
Welch-Aspin	0.01025	0.0106	0.0303	0.19095	0.55495	0.93465	*
Alexander-Govern	0.0101	0.0105	0.03015	0.1904	0.55415	0.9342	*
Yuen	0.0101	0.0105	0.03015	0.1904	0.55415	0.9342	*

Note: c = fraction or multiple of the population standard deviation.

Table 38. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0483	0.0493	0.0874	0.30965	0.64545	0.9399	*
Alexander-Govern	0.0481	0.04915	0.08715	0.3091	0.64505	0.93975	*
Yuen	0.0481	0.04915	0.08715	0.3091	0.64505	0.93975	*
	α = .01						
Welch-Aspin	0.00825	0.0084	0.02405	0.1275	0.38995	0.81115	0.99945
Alexander-Govern	0.0082	0.0084	0.02395	0.12725	0.38955	0.81075	0.99945
Yuen	0.0082	0.0084	0.02395	0.12725	0.38955	0.81075	0.99945

Note: c = fraction or multiple of the population standard deviation.

Table 39. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0504	0.05065	0.133	0.55845	0.9198	0.99945	*
Alexander-Govern	0.0502	0.0505	0.1327	0.5573	0.91945	0.99945	*
Yuen	0.0502	0.0505	0.1327	0.5573	0.91945	0.99945	*
	α = .01						
Welch-Aspin	0.0094	0.00965	0.0401	0.3121	0.782	0.99285	*
Alexander-Govern	0.00925	0.0096	0.0398	0.31115	0.7814	0.9928	*
Yuen	0.00925	0.0096	0.0398	0.31115	0.7814	0.9928	*

Note: c = fraction or multiple of the population standard deviation

Table 40. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:4, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:4			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0511	0.0515	0.1118	0.43995	0.8209	0.9912	*
Alexander-Govern	0.05105	0.0515	0.1117	0.43955	0.82065	0.9911	*
Yuen	0.05105	0.0515	0.1117	0.43955	0.82065	0.9911	*
	α = .01						
Welch-Aspin	0.00945	0.0097	0.03215	0.2137	0.61285	0.9551	*
Alexander-Govern	0.0094	0.0096	0.03215	0.2134	0.61235	0.955	*
Yuen	0.0094	0.0096	0.03215	0.2134	0.61235	0.955	*

Note: c = fraction or multiple of the population standard deviation.

Table 41. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=0	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04695	0.04685	0.0568	0.09585	0.17425	0.3383	0.7305
Alexander-Govern	0.0468	0.0467	0.05645	0.0956	0.174	0.3374	0.72995
Yuen	0.0468	0.0467	0.05645	0.0956	0.174	0.3374	0.72995
	α = .01						
Welch-Aspin	0.00875	0.00875	0.01035	0.02455	0.05665	0.14105	0.4754
Alexander-Govern	0.00875	0.0086	0.01025	0.02445	0.0565	0.14075	0.47465
Yuen	0.00875	0.0086	0.01025	0.02445	0.0565	0.14075	0.47465

Note: c = fraction or multiple of the population standard deviation.

Table 42. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=0	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0498	0.04995	0.05445	0.08255	0.13345	0.2422	0.5565
Alexander-Govern	0.04975	0.04995	0.0544	0.08245	0.1333	0.2418	0.5561
Yuen	0.04975	0.04995	0.0544	0.08245	0.1333	0.2418	0.5561
	α = .01						
Welch-Aspin	0.0104	0.0103	0.0115	0.021	0.0402	0.08775	0.28685
Alexander-Govern	0.0104	0.0103	0.0115	0.021	0.0402	0.0878	0.28685
Yuen	0.0104	0.0103	0.0115	0.021	0.0402	0.0878	0.28685

Note: c = fraction or multiple of the population standard deviation.

Table 43. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=0	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0518	0.0515	0.0674	0.15365	0.3181	0.6023	0.95985
Alexander-Govern	0.0516	0.05145	0.06725	0.15355	0.31785	0.60195	0.95985
Yuen	0.0516	0.05145	0.06725	0.15355	0.31785	0.60195	0.95985
	α = .01						
Welch-Aspin	0.0098	0.0098	0.01615	0.051	0.1358	0.3543	0.86145
Alexander-Govern	0.0097	0.0098	0.0161	0.051	0.1357	0.35395	0.86135
Yuen	0.0097	0.0098	0.0161	0.051	0.1357	0.35395	0.86135

Note: c = fraction or multiple of the population standard deviation.

Table 44. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=0	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0485	0.04865	0.0602	0.1166	0.2304	0.4446	0.8619
Alexander-Govern	0.0485	0.04865	0.0602	0.1166	0.2302	0.4445	0.86185
Yuen	0.0485	0.04865	0.0602	0.1166	0.2302	0.4445	0.86185
	α = .01						
Welch-Aspin	0.00885	0.0089	0.01335	0.0346	0.0832	0.21685	0.6568
Alexander-Govern	0.00885	0.0089	0.01335	0.03445	0.08315	0.2167	0.6567
Yuen	0.00885	0.0089	0.01335	0.03445	0.08315	0.2167	0.6567

Note: c = fraction or multiple of the population standard deviation.

Table 45. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=0	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.05115	0.0513	0.0733	0.2044	0.4463	0.781	0.99615
Alexander-Govern	0.05105	0.05125	0.07325	0.2043	0.4461	0.78085	0.99615
Yuen	0.05105	0.05125	0.07325	0.2043	0.4461	0.78085	0.99615
	α = .01						
Welch-Aspin	0.0095	0.00935	0.0176	0.0723	0.2191	0.5543	0.97485
Alexander-Govern	0.0094	0.00935	0.01755	0.0723	0.21875	0.55395	0.97485
Yuen	0.0094	0.00935	0.01755	0.0723	0.21875	0.55395	0.97485

Note: c = fraction or multiple of the population standard deviation.

Table 46. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=0	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0513	0.05155	0.0654	0.1548	0.3258	0.6178	0.963
Alexander-Govern	0.0513	0.05155	0.06535	0.15475	0.32575	0.61775	0.963
Yuen	0.0513	0.05155	0.06535	0.15475	0.32575	0.61775	0.963
	α = .01						
Welch-Aspin	0.00875	0.0087	0.01595	0.04975	0.13715	0.36785	0.87115
Alexander-Govern	0.00875	0.0087	0.0159	0.04965	0.1371	0.36785	0.87105
Yuen	0.00875	0.0087	0.0159	0.04965	0.1371	0.36785	0.87105

Note: c = fraction or multiple of the population standard deviation.

Table 47. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04695	0.04685	0.0568	0.09585	0.17425	0.3383	0.7305
Alexander-Govern	0.0468	0.0467	0.05645	0.0956	0.174	0.3374	0.72995
Yuen	0.0468	0.0467	0.05645	0.0956	0.174	0.3374	0.72995
	α = .01						
Welch-Aspin	0.00875	0.00875	0.01035	0.02455	0.05665	0.14105	0.4754
Alexander-Govern	0.00875	0.0086	0.01025	0.02445	0.0565	0.14075	0.47465
Yuen	0.00875	0.0086	0.01025	0.02445	0.0565	0.14075	0.47465

Note: c = fraction or multiple of the population standard deviation.

Table 48. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0498	0.04995	0.05445	0.08255	0.13345	0.2422	0.5565
Alexander-Govern	0.04975	0.04995	0.0544	0.08245	0.1333	0.2418	0.5561
Yuen	0.04975	0.04995	0.0544	0.08245	0.1333	0.2418	0.5561
	α = .01						
Welch-Aspin	0.0104	0.0103	0.0115	0.021	0.0402	0.08775	0.28685
Alexander-Govern	0.0104	0.0103	0.0115	0.021	0.0402	0.0878	0.28685
Yuen	0.0104	0.0103	0.0115	0.021	0.0402	0.0878	0.28685

Note: c = fraction or multiple of the population standard deviation.

Table 49. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0518	0.0515	0.0674	0.15365	0.3181	0.6023	0.95985
Alexander-Govern	0.0516	0.05145	0.06725	0.15355	0.31785	0.60195	0.95985
Yuen	0.0516	0.05145	0.06725	0.15355	0.31785	0.60195	0.95985
	α = .01						
Welch-Aspin	0.0098	0.0098	0.01615	0.051	0.1358	0.3543	0.86145
Alexander-Govern	0.0097	0.0098	0.0161	0.051	0.1357	0.35395	0.86135
Yuen	0.0097	0.0098	0.0161	0.051	0.1357	0.35395	0.86135

Note: c = fraction or multiple of the population standard deviation.

Table 50. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0485	0.04865	0.0602	0.1166	0.2304	0.4446	0.8619
Alexander-Govern	0.0485	0.04865	0.0602	0.1166	0.2302	0.4445	0.86185
Yuen	0.0485	0.04865	0.0602	0.1166	0.2302	0.4445	0.86185
	α = .01						
Welch-Aspin	0.00885	0.0089	0.01335	0.0346	0.0832	0.21685	0.6568
Alexander-Govern	0.00885	0.0089	0.01335	0.03445	0.08315	0.2167	0.6567
Yuen	0.00885	0.0089	0.01335	0.03445	0.08315	0.2167	0.6567

Note: c = fraction or multiple of the population standard deviation.

Table 51. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.05115	0.0513	0.0733	0.2044	0.4463	0.781	0.99615
Alexander-Govern	0.05105	0.05125	0.07325	0.2043	0.4461	0.78085	0.99615
Yuen	0.05105	0.05125	0.07325	0.2043	0.4461	0.78085	0.99615
	α = .01						
Welch-Aspin	0.0095	0.00935	0.0176	0.0723	0.2191	0.5543	0.97485
Alexander-Govern	0.0094	0.00935	0.01755	0.0723	0.21875	0.55395	0.97485
Yuen	0.0094	0.00935	0.01755	0.0723	0.21875	0.55395	0.97485

Note: c = fraction or multiple of the population standard deviation

Table 52. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0513	0.05155	0.0654	0.1548	0.3258	0.6178	0.963
Alexander-Govern	0.0513	0.05155	0.06535	0.15475	0.32575	0.61775	0.963
Yuen	0.0513	0.05155	0.06535	0.15475	0.32575	0.61775	0.963
	α = .01						
Welch-Aspin	0.00875	0.0087	0.01595	0.04975	0.13715	0.36785	0.87115
Alexander-Govern	0.00875	0.0087	0.0159	0.04965	0.1371	0.36785	0.87105
Yuen	0.00875	0.0087	0.0159	0.04965	0.1371	0.36785	0.87105

Note: c = fraction or multiple of the population standard deviation.

Table 53. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.04695	0.04685	0.0568	0.09585	0.17425	0.3383	0.7305
Alexander-Govern	0.0468	0.0467	0.05645	0.0956	0.174	0.3374	0.72995
Yuen	0.0468	0.0467	0.05645	0.0956	0.174	0.3374	0.72995
	α = .01						
Welch-Aspin	0.00875	0.00875	0.01035	0.02455	0.05665	0.14105	0.4754
Alexander-Govern	0.00875	0.0086	0.01025	0.02445	0.0565	0.14075	0.47465
Yuen	0.00875	0.0086	0.01025	0.02445	0.0565	0.14075	0.47465

Note: c = fraction or multiple of the population standard deviation.

Table 54. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0498	0.04995	0.05445	0.08255	0.13345	0.2422	0.5565
Alexander-Govern	0.04975	0.04995	0.0544	0.08245	0.1333	0.2418	0.5561
Yuen	0.04975	0.04995	0.0544	0.08245	0.1333	0.2418	0.5561
	α = .01						
Welch-Aspin	0.0104	0.0103	0.0115	0.021	0.0402	0.08775	0.28685
Alexander-Govern	0.0104	0.0103	0.0115	0.021	0.0402	0.0878	0.28685
Yuen	0.0104	0.0103	0.0115	0.021	0.0402	0.0878	0.28685

Note: c = fraction or multiple of the population standard deviation.

Table 55. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0518	0.0515	0.0674	0.15365	0.3181	0.6023	0.95985
Alexander-Govern	0.0516	0.05145	0.06725	0.15355	0.31785	0.60195	0.95985
Yuen	0.0516	0.05145	0.06725	0.15355	0.31785	0.60195	0.95985
	α = .01						
Welch-Aspin	0.0098	0.0098	0.01615	0.051	0.1358	0.3543	0.86145
Alexander-Govern	0.0097	0.0098	0.0161	0.051	0.1357	0.35395	0.86135
Yuen	0.0097	0.0098	0.0161	0.051	0.1357	0.35395	0.86135

Note: c = fraction or multiple of the population standard deviation.

Table 56. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0485	0.04865	0.0602	0.1166	0.2304	0.4446	0.8619
Alexander-Govern	0.0485	0.04865	0.0602	0.1166	0.2302	0.4445	0.86185
Yuen	0.0485	0.04865	0.0602	0.1166	0.2302	0.4445	0.86185
	α = .01						
Welch-Aspin	0.00885	0.0089	0.01335	0.0346	0.0832	0.21685	0.6568
Alexander-Govern	0.00885	0.0089	0.01335	0.03445	0.08315	0.2167	0.6567
Yuen	0.00885	0.0089	0.01335	0.03445	0.08315	0.2167	0.6567

Note: c = fraction or multiple of the population standard deviation.

Table 57. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.05115	0.0513	0.0733	0.2044	0.4463	0.781	0.99615
Alexander-Govern	0.05105	0.05125	0.07325	0.2043	0.4461	0.78085	0.99615
Yuen	0.05105	0.05125	0.07325	0.2043	0.4461	0.78085	0.99615
	α = .01						
Welch-Aspin	0.0095	0.00935	0.0176	0.0723	0.2191	0.5543	0.97485
Alexander-Govern	0.0094	0.00935	0.01755	0.0723	0.21875	0.55395	0.97485
Yuen	0.0094	0.00935	0.01755	0.0723	0.21875	0.55395	0.97485

Note: c = fraction or multiple of the population standard deviation.

Table 58. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Normal distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:16, Repetitions = 20,000

Normal	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:16			
c	0	0.01	0.2	0.5	0.8	1.2	2
Welch-Aspin	0.0513	0.05155	0.0654	0.1548	0.3258	0.6178	0.963
Alexander-Govern	0.0513	0.05155	0.06535	0.15475	0.32575	0.61775	0.963
Yuen	0.0513	0.05155	0.06535	0.15475	0.32575	0.61775	0.963
	α = .01						
Welch-Aspin	0.00875	0.0087	0.01595	0.04975	0.13715	0.36785	0.87115
Alexander-Govern	0.00875	0.0087	0.0159	0.04965	0.1371	0.36785	0.87105
Yuen	0.00875	0.0087	0.0159	0.04965	0.1371	0.36785	0.87105

Note: c = fraction or multiple of the population standard deviation.

Table 59. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=0	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.11465	0.47685	0.865	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4723	0.8633	0.9969	*
Yuen	0.0476	0.04725	0.1135	0.4723	0.8633	0.9969	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.2364	0.66845	0.9786	*
Alexander-Govern	0.00905	0.0091	0.03235	0.2327	0.66395	0.978	*
Yuen	0.00905	0.0091	0.03235	0.2327	0.66395	0.978	*

Note: c = fraction or multiple of the population standard deviation.

Table 60. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=0	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.108	0.4202	0.8204	0.9915	*
Alexander-Govern	0.0466	0.0475	0.1061	0.41655	0.81815	0.99145	*
Yuen	0.0466	0.0475	0.1061	0.41655	0.81815	0.99145	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.0295	0.19385	0.58025	0.95615	*
Alexander-Govern	0.01075	0.01045	0.0291	0.19095	0.57725	0.95515	*
Yuen	0.01075	0.01045	0.0291	0.19095	0.57725	0.95515	*

Note: c = fraction or multiple of the population standard deviation.

Table 61. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=0	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.1885	0.7774	0.99335	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.7757	0.9931	*	*
Yuen	0.0476	0.0479	0.18725	0.7757	0.9931	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.063	0.5501	0.96495	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54825	0.9643	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54825	0.9643	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 62. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=0	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.72365	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.7223	0.9859	*	*
Yuen	0.04775	0.0479	0.1727	0.7223	0.9859	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.4807	0.93305	0.9998	*
Alexander-Govern	0.00985	0.0098	0.05755	0.4782	0.93275	0.9998	*
Yuen	0.00985	0.0098	0.05755	0.4782	0.93275	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 63. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=0	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26375	0.91615	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.26285	0.91585	0.9998	*	*
Yuen	0.0487	0.0482	0.26285	0.91585	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.10385	0.7733	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.10285	0.7721	0.99745	*	*
Yuen	0.00965	0.00955	0.10285	0.7721	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 64. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=0	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.0488	0.2363	0.87945	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.87855	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.87855	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.0876	0.70535	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0871	0.70425	0.9938	*	*
Yuen	0.0106	0.0109	0.0871	0.70425	0.9938	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 65. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.11465	0.47685	0.865	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4723	0.8633	0.9969	*
Yuen	0.0476	0.04725	0.1135	0.4723	0.8633	0.9969	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.2364	0.66845	0.9786	*
Alexander-Govern	0.00905	0.0091	0.03235	0.2327	0.66395	0.978	*
Yuen	0.00905	0.0091	0.03235	0.2327	0.66395	0.978	*

Note: c = fraction or multiple of the population standard deviation.

Table 66. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.108	0.4202	0.8204	0.9915	*
Alexander-Govern	0.0466	0.0475	0.1061	0.41655	0.81815	0.99145	*
Yuen	0.0466	0.0475	0.1061	0.41655	0.81815	0.99145	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.0295	0.19385	0.58025	0.95615	*
Alexander-Govern	0.01075	0.01045	0.0291	0.19095	0.57725	0.95515	*
Yuen	0.01075	0.01045	0.0291	0.19095	0.57725	0.95515	*

Note: c = fraction or multiple of the population standard deviation.

Table 67. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.1885	0.7774	0.99335	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.7757	0.9931	*	*
Yuen	0.0476	0.0479	0.18725	0.7757	0.9931	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.063	0.5501	0.96495	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54825	0.9643	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54825	0.9643	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 68. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.72365	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.7223	0.9859	*	*
Yuen	0.04775	0.0479	0.1727	0.7223	0.9859	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.4807	0.93305	0.9998	*
Alexander-Govern	0.00985	0.0098	0.05755	0.4782	0.93275	0.9998	*
Yuen	0.00985	0.0098	0.05755	0.4782	0.93275	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 69. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26375	0.91615	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.26285	0.91585	0.9998	*	*
Yuen	0.0487	0.0482	0.26285	0.91585	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.10385	0.7733	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.10285	0.7721	0.99745	*	*
Yuen	0.00965	0.00955	0.10285	0.7721	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 70. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.0488	0.2363	0.87945	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.87855	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.87855	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.0876	0.70535	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0871	0.70425	0.9938	*	*
Yuen	0.0106	0.0109	0.0871	0.70425	0.9938	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 71. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.11465	0.47685	0.865	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4723	0.8633	0.9969	*
Yuen	0.0476	0.04725	0.1135	0.4723	0.8633	0.9969	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.2364	0.66845	0.9786	*
Alexander-Govern	0.00905	0.0091	0.03235	0.2327	0.66395	0.978	*
Yuen	0.00905	0.0091	0.03235	0.2327	0.66395	0.978	*

Note: c = fraction or multiple of the population standard deviation.

Table 72. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.108	0.4202	0.8204	0.9915	*
Alexander-Govern	0.0466	0.0475	0.1061	0.41655	0.81815	0.99145	*
Yuen	0.0466	0.0475	0.1061	0.41655	0.81815	0.99145	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.0295	0.19385	0.58025	0.95615	*
Alexander-Govern	0.01075	0.01045	0.0291	0.19095	0.57725	0.95515	*
Yuen	0.01075	0.01045	0.0291	0.19095	0.57725	0.95515	*

Note: c = fraction or multiple of the population standard deviation.

Table 73. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.1885	0.7774	0.99335	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.7757	0.9931	*	*
Yuen	0.0476	0.0479	0.18725	0.7757	0.9931	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.063	0.5501	0.96495	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54825	0.9643	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54825	0.9643	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 74. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.72365	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.7223	0.9859	*	*
Yuen	0.04775	0.0479	0.1727	0.7223	0.9859	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.4807	0.93305	0.9998	*
Alexander-Govern	0.00985	0.0098	0.05755	0.4782	0.93275	0.9998	*
Yuen	0.00985	0.0098	0.05755	0.4782	0.93275	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 75. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26375	0.91615	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.26285	0.91585	0.9998	*	*
Yuen	0.0487	0.0482	0.26285	0.91585	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.10385	0.7733	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.10285	0.7721	0.99745	*	*
Yuen	0.00965	0.00955	0.10285	0.7721	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation

Table 76. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:1, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:1			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.0488	0.2363	0.87945	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.87855	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.87855	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.0876	0.70535	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0871	0.70425	0.9938	*	*
Yuen	0.0106	0.0109	0.0871	0.70425	0.9938	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 77. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=0	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.1148	0.477	0.86505	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
Yuen	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.23675	0.66885	0.97875	*
Alexander-Govern	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*
Yuen	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*

Note: c = fraction or multiple of the population standard deviation.

Table 78. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=0	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.10795	0.42035	0.8206	0.9915	*
Alexander-Govern	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
Yuen	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.02955	0.1942	0.58085	0.95625	*
Alexander-Govern	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*
Yuen	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*

Note: c = fraction or multiple of the population standard deviation.

Table 79. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=0	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.18865	0.7777	0.99345	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
Yuen	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.06315	0.5506	0.6515	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 80. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=0	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.7241	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
Yuen	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.48115	0.93325	0.9998	*
Alexander-Govern	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*
Yuen	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 81. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =0, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=0	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26395	0.9165	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.263	0.91605	0.9998	*	*
Yuen	0.0487	0.0482	0.263	0.91605	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.104	0.77355	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.1029	0.7726	0.99745	*	*
Yuen	0.00965	0.00955	0.1029	0.7726	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 82. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=0	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.04885	0.23655	0.8796	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.879	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.879	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.08785	0.7058	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0872	0.70455	0.99385	*	*
Yuen	0.0106	0.0109	0.0872	0.70455	0.99385	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 83. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.1148	0.477	0.86505	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
Yuen	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.23675	0.66885	0.97875	*
Alexander-Govern	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*
Yuen	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*

Note: c = fraction or multiple of the population standard deviation.

Table 84. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.10795	0.42035	0.8206	0.9915	*
Alexander-Govern	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
Yuen	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.02955	0.1942	0.58085	0.95625	*
Alexander-Govern	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*
Yuen	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*

Note: c = fraction or multiple of the population standard deviation.

Table 85. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.18865	0.7777	0.99345	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
Yuen	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.06315	0.5506	0.6515	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 86. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.7241	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
Yuen	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.48115	0.93325	0.9998	*
Alexander-Govern	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*
Yuen	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 87. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.1, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26395	0.9165	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.263	0.91605	0.9998	*	*
Yuen	0.0487	0.0482	0.263	0.91605	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.104	0.77355	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.1029	0.7726	0.99745	*	*
Yuen	0.00965	0.00955	0.1029	0.7726	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation

Table 88. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.04885	0.23655	0.8796	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.879	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.879	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.08785	0.7058	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0872	0.70455	0.99385	*	*
Yuen	0.0106	0.0109	0.0872	0.70455	0.99385	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 89. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.1148	0.477	0.86505	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
Yuen	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.23675	0.66885	0.97875	*
Alexander-Govern	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*
Yuen	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*

Note: c = fraction or multiple of the population standard deviation.

Table 90. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.10795	0.42035	0.8206	0.9915	*
Alexander-Govern	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
Yuen	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.02955	0.1942	0.58085	0.95625	*
Alexander-Govern	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*
Yuen	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*

Note: c = fraction or multiple of the population standard deviation.

Table 91. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.18865	0.7777	0.99345	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
Yuen	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.06315	0.5506	0.6515	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 92. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.7241	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
Yuen	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.48115	0.93325	0.9998	*
Alexander-Govern	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*
Yuen	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 93. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.2, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26395	0.9165	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.263	0.91605	0.9998	*	*
Yuen	0.0487	0.0482	0.263	0.91605	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.104	0.77355	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.1029	0.7726	0.99745	*	*
Yuen	0.00965	0.00955	0.1029	0.7726	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation

Table 94. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:4, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:4			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.04885	0.23655	0.8796	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.879	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.879	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.08785	0.7058	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0872	0.70455	0.99385	*	*
Yuen	0.0106	0.0109	0.0872	0.70455	0.99385	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 95. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=0	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.1148	0.477	0.86505	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
Yuen	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.23675	0.66885	0.97875	*
Alexander-Govern	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*
Yuen	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*

Note: c = fraction or multiple of the population standard deviation.

Table 96. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=0	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.10795	0.42035	0.8206	0.9915	*
Alexander-Govern	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
Yuen	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.02955	0.1942	0.58085	0.95625	*
Alexander-Govern	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*
Yuen	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*

Note: c = fraction or multiple of the population standard deviation.

Table 97. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=0	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.18865	0.7777	0.99345	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
Yuen	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.06315	0.5506	0.6515	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 98. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=0	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.7241	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
Yuen	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.48115	0.93325	0.9998	*
Alexander-Govern	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*
Yuen	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 99. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =0, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=0	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26395	0.9165	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.263	0.91605	0.9998	*	*
Yuen	0.0487	0.0482	0.263	0.91605	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.104	0.77355	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.1029	0.7726	0.99745	*	*
Yuen	0.00965	0.00955	0.1029	0.7726	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 100. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=0	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.04885	0.23655	0.8796	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.879	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.879	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.08785	0.7058	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0872	0.70455	0.99385	*	*
Yuen	0.0106	0.0109	0.0872	0.70455	0.99385	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 101. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.1148	0.477	0.86505	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
Yuen	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.23675	0.66885	0.97875	*
Alexander-Govern	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*
Yuen	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*

Note: c = fraction or multiple of the population standard deviation.

Table 102. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.10795	0.42035	0.8206	0.9915	*
Alexander-Govern	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
Yuen	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.02955	0.1942	0.58085	0.95625	*
Alexander-Govern	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*
Yuen	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*

Note: c = fraction or multiple of the population standard deviation.

Table 103. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.18865	0.7777	0.99345	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
Yuen	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.06315	0.5506	0.6515	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 104. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.7241	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
Yuen	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.48115	0.93325	0.9998	*
Alexander-Govern	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*
Yuen	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 105. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.1, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26395	0.9165	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.263	0.91605	0.9998	*	*
Yuen	0.0487	0.0482	0.263	0.91605	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.104	0.77355	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.1029	0.7726	0.99745	*	*
Yuen	0.00965	0.00955	0.1029	0.7726	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 106. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.04885	0.23655	0.8796	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.879	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.879	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.08785	0.7058	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0872	0.70455	0.99385	*	*
Yuen	0.0106	0.0109	0.0872	0.70455	0.99385	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 107. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04845	0.04785	0.1148	0.477	0.86505	0.99705	*
Alexander-Govern	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
Yuen	0.0476	0.04725	0.1135	0.4726	0.86375	0.99695	*
	α = .01						
Welch-Aspin	0.00925	0.00945	0.03315	0.23675	0.66885	0.97875	*
Alexander-Govern	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*
Yuen	0.00905	0.0091	0.03235	0.23315	0.6643	0.9781	*

Note: c = fraction or multiple of the population standard deviation.

Table 108. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04795	0.0478	0.10795	0.42035	0.8206	0.9915	*
Alexander-Govern	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
Yuen	0.0466	0.0475	0.10615	0.41685	0.81845	0.9915	*
	α = .01						
Welch-Aspin	0.0109	0.0108	0.02955	0.1942	0.58085	0.95625	*
Alexander-Govern	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*
Yuen	0.01075	0.01045	0.02915	0.19115	0.5776	0.95525	*

Note: c = fraction or multiple of the population standard deviation.

Table 109. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.04835	0.0483	0.18865	0.7777	0.99345	*	*
Alexander-Govern	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
Yuen	0.0476	0.0479	0.18725	0.77605	0.9932	*	*
	α = .01						
Welch-Aspin	0.00995	0.01025	0.06315	0.5506	0.6515	0.9999	*
Alexander-Govern	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*
Yuen	0.00955	0.01015	0.0625	0.54845	0.9645	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 110. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0481	0.04845	0.17335	0.7241	0.9863	*	*
Alexander-Govern	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
Yuen	0.04775	0.0479	0.1727	0.72245	0.9861	*	*
	α = .01						
Welch-Aspin	0.01005	0.00985	0.05825	0.48115	0.93325	0.9998	*
Alexander-Govern	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*
Yuen	0.00985	0.0098	0.0576	0.47875	0.93285	0.9998	*

Note: c = fraction or multiple of the population standard deviation.

Table 111. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.2, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0489	0.0488	0.26395	0.9165	0.9998	*	*
Alexander-Govern	0.0487	0.0482	0.263	0.91605	0.9998	*	*
Yuen	0.0487	0.0482	0.263	0.91605	0.9998	*	*
	α = .01						
Welch-Aspin	0.0097	0.00965	0.104	0.77355	0.99745	*	*
Alexander-Govern	0.00965	0.00955	0.1029	0.7726	0.99745	*	*
Yuen	0.00965	0.00955	0.1029	0.7726	0.99745	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 112. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:16, Repetitions = 20,000

Uniform	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:16			
c	0	0.00288765	0.057753	0.1443825	0.231012	0.346518	0.57753
Welch-Aspin	0.0503	0.04885	0.23655	0.8796	0.99895	*	*
Alexander-Govern	0.0499	0.0483	0.23545	0.879	0.99895	*	*
Yuen	0.0499	0.0483	0.23545	0.879	0.99895	*	*
	α = .01						
Welch-Aspin	0.0108	0.011	0.08785	0.7058	0.99395	*	*
Alexander-Govern	0.0106	0.0109	0.0872	0.70455	0.99385	*	*
Yuen	0.0106	0.0109	0.0872	0.70455	0.99385	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 113. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=0	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 114. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=0	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 115. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=0	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 116. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=0	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 117. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=0	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 118. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=0	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 119. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim = .1 , Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:1		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 120. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim =.1 , Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 121. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =.1, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:1		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 122. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 123. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:1		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 124. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:1		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 125. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim = .2 Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 126. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 127. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =.2, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 128. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim =.2, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 129. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.2, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 130. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:1, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:1			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 131. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 132. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 133. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 134. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 135. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 136. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 137. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:4		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 138. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim =.1, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 139. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =.1, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 140. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 141. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 142. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=0	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 143. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 144. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim =.2, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 145. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =.2, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:4		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 146. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 147. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 148. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:4, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:4			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 149. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim =0, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=0	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 150. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim =0, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=0	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 151. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =0, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=0	Scale = 1:16		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 152. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=0	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 153. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =0, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=0	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 154. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=0	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 155. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim =.1, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 156. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim =.1, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 157. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =.1, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:16		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 158. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim =.1, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 159. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.1, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:16		
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 160. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 161. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (30,30), Trim =.2, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.0472	0.04795	0.1234	0.5041	0.85325	0.9883	0.99995
Alexander-Govern	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
Yuen	0.0465	0.047	0.1217	0.50135	0.85185	0.98795	0.99995
	α = .01						
Welch-Aspin	0.0088	0.0089	0.03495	0.26795	0.6844	0.9542	0.99985
Alexander-Govern	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985
Yuen	0.00865	0.00855	0.03405	0.2643	0.681	0.9536	0.99985

Note: c = fraction or multiple of the population standard deviation.

Table 162. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (20,40), Trim =.2, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05215	0.05065	0.0858	0.43765	0.8538	0.99385	*
Alexander-Govern	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
Yuen	0.05125	0.04965	0.08485	0.43465	0.8512	0.9936	*
	α = .01						
Welch-Aspin	0.01105	0.01015	0.01445	0.17975	0.6268	0.9654	*
Alexander-Govern	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*
Yuen	0.01075	0.0101	0.0144	0.17725	0.6227	0.96455	*

Note: c = fraction or multiple of the population standard deviation.

Table 163. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,60), Trim =.2, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04685	0.0479	0.19825	0.7779	0.98765	0.99985	*
Alexander-Govern	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
Yuen	0.04655	0.04735	0.1974	0.7768	0.98765	0.99985	*
	α = .01						
Welch-Aspin	0.00735	0.00725	0.06685	0.5595	0.94815	0.99965	*
Alexander-Govern	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*
Yuen	0.00725	0.00715	0.0665	0.5578	0.9476	0.99965	*

Note: c = fraction or multiple of the population standard deviation.

Table 164. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (40,80), Trim =.2, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05075	0.048	0.1503	0.75335	0.98985	*	*
Alexander-Govern	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
Yuen	0.0502	0.0474	0.14955	0.75225	0.98975	*	*
	α = .01						
Welch-Aspin	0.01105	0.00975	0.0377	0.49455	0.9528	0.99995	*
Alexander-Govern	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*
Yuen	0.0108	0.00965	0.0374	0.4924	0.95225	0.99995	*

Note: c = fraction or multiple of the population standard deviation.

Table 165. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Uniform distribution, α = 0.05, Sample Size = (90,90), Trim =.2, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.04805	0.04775	0.27895	0.912	0.99945	*	*
Alexander-Govern	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
Yuen	0.0477	0.04745	0.27815	0.91155	0.99945	*	*
	α = .01						
Welch-Aspin	0.00905	0.00955	0.11015	0.77245	0.99505	*	*
Alexander-Govern	0.00895	0.0095	0.1095	0.7714	0.99505	*	*
Yuen	0.00895	0.0095	0.1095	0.7714	0.99505	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 166. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Exponential distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:16, Repetitions = 20,000

Exponential	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:16			
c	0	0.02002184	0.4004368	1.001092	1.6017472	2.4026208	4.004368
Welch-Aspin	0.05255	0.05085	0.2254	0.90255	0.9995	*	*
Alexander-Govern	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
Yuen	0.05225	0.05035	0.22465	0.90225	0.9995	*	*
	α = .01						
Welch-Aspin	0.01305	0.01195	0.06975	0.73255	0.9959	*	*
Alexander-Govern	0.0129	0.0118	0.0691	0.7315	0.9958	*	*
Yuen	0.0129	0.0118	0.0691	0.7315	0.9958	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 167. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=0	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 168. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=0	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 169. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=0	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 170. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=0	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 171. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=0	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 172. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=0	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 173. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 174. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 175. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 176. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 177. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 178. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 179. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 180. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 181. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 182. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 183. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 184. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:1, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:1			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 185. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim = 0, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=0	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 186. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim = 0, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=0	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 187. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim = 0, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=0	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 188. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim = 0, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=0	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 189. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim = 0, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=0	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 190. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim = 0, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=0	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 191. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim = .1, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 192. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim = .1, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 193. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim = .1, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 194. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim = .1, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 195. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim = .1, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 196. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim = .1, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 197. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim = .2, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 198. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim = .2, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 199. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim = .2, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 200. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim = .2, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 201. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim = .2, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 202. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim = .2, Scale = 1:4, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:4			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 203. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim =0, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=0	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 204. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim =0, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=0	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 205. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim =0, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=0	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 206. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim =0, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=0	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 207. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim =0, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=0	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 208. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim =0, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=0	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 209. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=.1	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 210. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=.1	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 211. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=.1	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 212. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=.1	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 213. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=.1	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 214. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=.1	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

Table 215. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (30,30), Trim =.2, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 30,30	Trim=.2	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0454	0.046	0.12315	0.4953	0.85835	0.9927	*
Alexander-Govern	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
Yuen	0.04435	0.04535	0.1219	0.4922	0.8571	0.9925	*
	α = .01						
Welch-Aspin	0.00775	0.00765	0.03435	0.26475	0.681	0.9629	0.99995
Alexander-Govern	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995
Yuen	0.0075	0.0075	0.03365	0.26105	0.6774	0.9625	0.99995

Note: c = fraction or multiple of the population standard deviation.

Table 216. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (20,40), Trim =.2, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 20,40	Trim=.2	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0506	0.04885	0.0854	0.4254	0.8468	0.99465	*
Alexander-Govern	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
Yuen	0.0499	0.04805	0.08405	0.42235	0.8447	0.9943	*
	α = .01						
Welch-Aspin	0.0107	0.0099	0.01665	0.17255	0.6126	0.96575	*
Alexander-Govern	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*
Yuen	0.01055	0.0096	0.0163	0.17055	0.60925	0.9651	*

Note: c = fraction or multiple of the population standard deviation.

Table 217. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,60), Trim =.1, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,60	Trim=.2	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.0513	0.05125	0.19885	0.77675	0.98885	*	*
Alexander-Govern	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
Yuen	0.05085	0.05085	0.19765	0.77535	0.9888	*	*
	α = .01						
Welch-Aspin	0.0103	0.0105	0.07175	0.562	0.9533	0.9999	*
Alexander-Govern	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*
Yuen	0.0101	0.0104	0.0712	0.56	0.95285	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 218. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (40,80), Trim =.2, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 40,80	Trim=.2	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.052	0.05095	0.15685	0.74385	0.9913	*	*
Alexander-Govern	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
Yuen	0.0518	0.0502	0.1558	0.7426	0.99115	*	*
	α = .01						
Welch-Aspin	0.0111	0.0105	0.0442	0.4881	0.95245	0.9999	*
Alexander-Govern	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*
Yuen	0.01095	0.01045	0.0438	0.4859	0.9517	0.9999	*

Note: c = fraction or multiple of the population standard deviation.

Table 219. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (90,90), Trim =.2, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 90,90	Trim=.2	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04885	0.04905	0.26875	0.91515	0.9995	*	*
Alexander-Govern	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
Yuen	0.0488	0.0488	0.26775	0.91475	0.9995	*	*
	α = .01						
Welch-Aspin	0.00935	0.0099	0.11	0.772	0.99575	*	*
Alexander-Govern	0.00925	0.00985	0.1093	0.7707	0.99565	*	*
Yuen	0.00925	0.00985	0.1093	0.7707	0.99565	*	*

Note: c = fraction or multiple of the population standard deviation

Table 220. Type I Error and Power of the Welch-Aspin, Alexander-Govern, and Yuen's Test for Chi-squared distribution, α = 0.05, Sample Size = (60,120), Trim =.2, Scale = 1:16, Repetitions = 20,000

Chi-squared	α = 0.05	ss = 60,120	Trim=.2	Scale = 1:16			
c	0	0.02447308	0.4894616	1.223654	1.9578464	2.9367696	4.894616
Welch-Aspin	0.04905	0.0483	0.22205	0.898	0.99975	*	*
Alexander-Govern	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
Yuen	0.04885	0.04815	0.22125	0.8975	0.99975	*	*
	α = .01						
Welch-Aspin	0.01035	0.0097	0.0724	0.7262	0.996	*	*
Alexander-Govern	0.0103	0.0097	0.0719	0.72505	0.99595	*	*
Yuen	0.0103	0.0097	0.0719	0.72505	0.99595	*	*

Note: c = fraction or multiple of the population standard deviation.

CHAPTER 5 CONCLUSION AND DISSCUSSION

The main purpose of this Monte Carlo Simulation was to compare the Yuen, Alexander-Govern, and Welch-Aspin tests to determine their comparative statistical power under parametric assumption violations (i.e., normality, homoscedasticity). Hence, the Type I and Type-II error rejection rates were obtained under the conditions of nonnormality and heteroscedasticity, along with the power spectrum as the location increases from 0 to 2σ, where σ represented the standard deviation of the population being sampled. The reason for including the Welch-Aspin test in this comparison research was it serves as a comparison baseline for the other tests, being the standard adjustment to the parametric t test. When there were heavy tails or outliers in the data. Yuen test presumably would be superior, and the Alexander-Govern test included because it to was designed to handle the problem of variance heterogeneity. Type I and Type-II error rejection rates.

Type I Error Rejection Rates:

An examination of the Type I error rates of the three tests confirmed that all three tests were robust to departures from population normality. The rejection rates of the three tests were consistently close to the nominal alpha at .05 and .01. Similarly, all three tests were equally robust when both the assumption of normality and homoscedasticity was violated.

Based on Bradley's (1978) liberal criterion of robustness, a test can be considered robust if rate of Type I error, is within the interval 0.5α and 1.5α. For the nominal level $\alpha = 0.05$, the Type I error rate should be between 0.025 and 0.075. Similarly, if the nominal level is $\alpha = 0.01$, the empirical Type I error rate should be within interval $.005 < \alpha < .015$. When examining each statistic for robustness with respect to Type I errors for the normal distribution particularly, when there is no shift in means c = 0, all three tests were consistently robust with regard to Type I error. The results indicated that the three tests maintained generally robust rejection rates that were close to the nominal alpha at .05 and .01. However, It is been indicated in results data that there was no difference in the third decimal place, and often not even in the fourth decimal place, between the three tests.

Table 221 contains maximum deviation from nominal alpha of Welch-Aspin, Alexander and Yuen tests for the normal distribution, no treatment effect. Specifically, in table for the nonnormal distributions considered (i.e., uniform, exponential and chi-squared), results demonstrated all three tests were robust and maintained generally robust rejection rates that were close to the nominal alpha at .05 and .01 when there was no shift in means. Therefore, it can be concluded that the three tests are equally robust with respect to departures from both normality and to homoscedasticity.

Table 221. Maximum deviation from nominal alpha of Welch-Aspin, Alexander and Yuen tests for the normal distribution, no treatment effect.

Alpha	Normal	Uniform	Exponential	Chi-squared
0.05	-0.002	-0.003	-0.003	-0.002
0.01	-0.0005	-0.0008	-0.0008	-0.0003

Type II Error Rejection Rates:

Similarly, the results in table 222 indicated the reject rates obtained under the nonnormal distribution for the various levels of shift in location, different balanced and unbalanced sample sizes, two alpha levels (i.e., .05 and .01), amounts of trim (i.e., 10%, 20%) and changes in scale (i.e., 1:4 and 1:6) were nearly identical to the rejection rates obtained under the normal distribution. This indicates all three tests were robust with respect to Type II errors for departures of the underlying assumptions of normality and homoscedasticity.

Table 222. Maximum deviation in rejection rate compared with normality for Welch-Aspin, Alexander and Yuen tests, all treatment conditions.

Robust II	α = 0.05					
c	0.01	0.2	0.5	0.8	1.2	2
Uniform	0.0036	-0.0009	-0.0011	0.0000	0.0000	0.0000
Exponential	0.0016	-0.0006	-0.0161	0.0003	0.0000	0.0000
Chi-squared	0.0012	-0.0006	-0.0059	0.0001	0.0000	0.0000
	α = .01					
Uniform	0.0000	-0.0004	0.001	-0.0011	0.0000	0.0000
Exponential	-0.0009	-0.0064	0.002	0.0004	0.0000	0.0000
Chi-squared	0.0005	-0.0064	0.002	0.0004	0.0000	0.0000

Comparative Power

Table 223 cantinas the power spectrums for the Welsh-Aspin, Yuen, and Alexander-Govern tests were nearly identical, regardless of the study condition, for a total of 60 treatment conditions.

Table 223. Maximum difference in comparative power between the three tests, for all treatment conditions.

Comparative Power	α = 0.05					
c	0.01	0.2	0.5	0.8	1.2	2
Normal	0.0002	0.0006	0.0015	0.0012	0.0012	0.0009
Uniform	0.0016	0.0010	0.0013	0.0013	0.0016	0.0000
Exponential	0.0012	0.0021	0.4774	0.0003	0.0121	0.0001
Chi-squared	0.0012	0.0017	0.0019	0.0013	0.0075	0.0000
	α = .01					
Normal	0.0010	0.0033	0.0003	0.0018	0.0013	0.0003
Uniform	0.0019	0.0012	0.0013	0.0012	0.0008	0.0000
Exponential	0.0004	0.0018	0.0012	0.0012	0.0004	0.0000
Chi-squared	0.0003	0.0007	0.0006	0.0001	0.0003	0.0001

Recommendation

The purpose of this study was to compare the robustness and comparative power of the Welch-Aspin, Yuen, and the Alexander-Govern tests when the underlying assumptions of normality (i.e., uniform, exponential, Chi-squared) and homogeneity of variances assumptions (i.e., 1:4, 1:16) are violated. The results indicated all three tests were highly robust with respect to Type I and Type II errors for departures from these underlying assumptions, and are equally powerful for the treatment conditions studied. On this basis, there is no advantage or disadvantage in using any of these three tests.

However, there were study parameters not considered in this Monte Carlo experiment that should be given consideration in future research. For example, Yuen's test is particularly powerful in the presence of outliers, which were defined in this study only as nonnormal distributions. The results may favor Yuen’s test for data sampled from a population (normal or otherwise) with perturbations, such as a few (or a few percent) extreme values on one or both sides of the sample. On other words, data sampled from a population with outliers was not considered. Yuen test, based on trimming outliers, may have an advantage, so in a future study, I consider that condition

Another study parameter not considered here is when the data for one group is obtained from a variable with one distributional shape and the data for the other group is obtained from a variable with a different distributional shape. In this study, the distributions of both groups were identical. In a future study I might create groups by sampling different distributions. An example might be a treatment group with scores distributed exponentially, while the comparison group’s scores are distributed normally. Yet another possible study condition is with real data, that often have more extreme shapes than those of the mathematical distributions considered.

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ABSTRACT

ROBUSTNESS AND COMPARATIVE POWER OF WELCH-ASPIN, ALEXANDER-GOVERN AND YUEN TESTS UNDER NON-NORMALITY AND VARIANCE HETEROSCEDASTICITY

by

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Classical statistical tests are used in many disciplines such as education and psychology. Such tests are based on certain assumptions (e.g., normality and homoscedasticity) that are must to be met in order to produce accurate results. Violation of such assumptions is a common problem researchers encounter, particularly when analyzing real data. When such assumptions are violated, the effectiveness and efficiency of tests to control over the probability of a Type I error and maintain a relatively level of statistical power will be substantially affected.

Alternative modern and robust statistical tests such as Welch-Aspin test, Yuen test for trimmed means and the Alexander-Govern test can be used to overcome these assumption violations. The purpose of present study, then, is to research and explicate under non-normal and heteroscedastic conditions if Welch-Aspin test, Yuen test, and Alexander-Govern test is more robust with respect to Type I and Type II errors while maintaining a power advantage for detecting changes/differences in scale and location shifts.

The result of the simulations indicated that under the four distributions, all scales; 1:1,1:4,1:16, alpha levels, and sample sizes, Welch-Aspin, Yuen, and Alexander-Govern tests were similar to be more robust tests to Type I errors and held a power advantage for detecting changes/differences in scale and location shifts. However, the results indicated that the effect size was the main condition that effects the Type I and II rejection and the power level as well for all the three competitors statistics.

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