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The Implementation of Soundscape Composition to Identify the Ideal Soundscape for Various Activities

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Highlights:

- The concept of soundscape composition using an acoustic environment simulator was implemented to identify the ideal acoustic environment and perception for doing four different activities.
- Individual activities were expected to be done in a relaxing, simple, and private environment, while social activities were expected to be done in a less relaxing, varied, and communal situation.
- Individual activities were expected to be done in an environment dominated by natural sounds and slow music, while social activities were expected to be done in an environment dominated by sounds of human activity.
- Each activity was expected to have different sound sources.

Abstract. Soundscapes are affected by several factors and one of them is the activities done in the space concerned. People expect different acoustic environments for different activities, but there is no specific guidance for designing an ideal acoustic environment for different activities. This study aimed to identify ideal urban acoustic environments for four different activities: reading, relaxing, talking with friends, and playing with children. The ideal acoustic environment was evaluated using the soundscape composition concept. The concept was implemented by an acoustic environment simulator that enabled the respondents to compose their ideal acoustic environment and identify the perception of their composition. The sound source selection and perception rating were analyzed to understand the ideal acoustic environment and perception for different activities. This study identified the ideal soundscapes for four different activities and the perception expected to be present in the ideal environments for those activities. The result can be beneficial as guidance for urban soundscape design.

Keywords: *acoustic environment simulator; activities; sound source; soundscape; soundscape composition.*

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1 Introduction

Many studies have shown that there is a relationship between soundscape and activities. Understanding this relationship is one of the priorities of soundscape studies [1]. The study conducted by Jennings & Cain showed that the engagement with the soundscape in urban areas is affected by the activity done [2]. Bild, *et al.* state that people evaluate the acoustic environment differently according to the expected activities in that area [3]. Another study investigated a soundscape intervention using classical music and found that people stayed to enjoy an urban area longer with music playing [4]. A survey by Chiesura [5] using interviews revealed that an urban space dominated by natural sounds is suitable for relaxing activities. The study conducted by Guastavino, *et al.* [6] showed that the sound of human activities is ideal for urban soundscapes for social activities. These previous studies have shown that, in general, there is an interaction between soundscape and activities. However, the interaction between specific activities and soundscapes has not been identified yet. Therefore, it cannot be used as a guide to design an acoustic environment. Detailed identification was not done mainly because of the methods used in the previous studies.

These studies were usually conducted by representing the soundscape in situ [7] or in a laboratory using recordings [8]. The participants were asked about their opinion and the rating of the stimulus. Such methods cannot provide detailed information because the acoustic environment cannot be modified, resulting in a limited stimulus. Furthermore, the data from these kinds of experiments only provide a list of activities done in those acoustic environments, which is insufficient as design guidance. Another approach uses artificial stimuli that are composed using several different sound sources [9]. This method is able to quantify the specific relation between several different sound sources and the perception of an acoustic environment. However, in this case, the sound source combinations were limited due to the limited time of the experiment. The relationship was only based on the sound sources used in the experiment. A different approach is based on people's memory. This is done using an interview protocol [10]. Although this method can be used to access many acoustic environments, the information is still too general. It cannot be used as specific design guidance.

Using the composition concept may help identify the relationship between specific activities and a soundscape. Soundscape composition is a method that allows participants to compose a particular soundscape according to their expectations [11]. This method implements an acoustic environment simulator developed to understand people's expectations of sound sources in an acoustic environment [12]. This simulator has been validated for soundscape studies [13]. It has been utilized to understand the relationship between sound sources and

perception in urban areas [14]. The specific relationship between a soundscape and different activities can be determined by requesting the participants to compose their ideal acoustic environments for particular activities. The relationship is focused on two aspects: the sound sources in the ideal acoustic environment and the perception that emerges from this environment. The result is beneficial as guidance for acoustic environment design.

2 Experimental Method

An experiment was conducted using an acoustic environment simulator in an acoustically treated room. The room meet to 27 noise criteria and had a reverberation time of 0.23 s. In the experiment, the participants were asked to compose four acoustic environments suitable for the following activities: relaxation, reading a book, talking with each other, and playing with children (see Figure 1). The activities were selected to represent different individual and social activities in an urban area that have been used in a previous study [15]. The different activities were chosen to identify the various sound sources expected for multiple activities. Previous research has shown that each acoustic environment is unique and therefore different sound sources are expected [11]. After each composition, the participants were asked to rate the composed soundscape on a scale of relaxation, dynamic, and communication. The scale was selected based on reliable dimensions in urban areas [8]. The perception was rated on an 11-point Likert scale (-5 to 5). The experiment lasted for approximately 30 minutes.

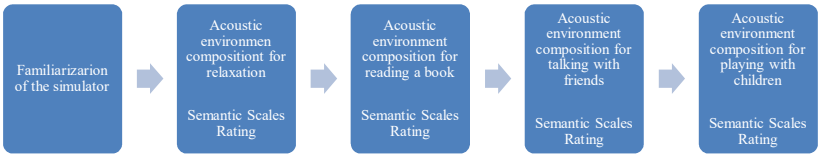

Figure 1 Steps of the experiment.

Fifty-one participants voluntarily joined the experiment. All participants were students of Institute Teknologi Bandung, with the majority coming from the Department of Engineering Physics. Engineering students were selected because a previous study conducted by Martokusumo, *et al.* [16] found that respondents with a background other than design are more suitable to represent the general population. The age of the participants varied from 18-25 years; 61% of the participants were 21 years old. 53% of the participants were female and 47% were male. The following data from the experiment were analyzed: the rating of perception from semantic scale ('relaxation,' 'dynamic,' and 'communication') of each composition, and the selection of sound sources from each composition. In total, 204 acoustic environment compositions were analyzed. The method used

in this study was similar to that used in previous studies conducted to identify the relationship between sound sources and perception [13] and to identify the improvement of urban areas [17].

3 Acoustics Environment Simulator

An acoustic environment simulator is a system that allows people to compose an acoustic environment in real time using the concept of ambisonic reproduction. The acoustic environment simulator was developed based on a previous acoustic environment simulator [13]; the simulator used in this experiment was adjusted to fit the context of Indonesia. The adjustment was made by selecting sound sources that exist in urban areas in Indonesia. The sound sources were recorded in various urban parks in Bandung (Indonesia) using a Rode NTG1 shotgun microphone and a Zoom H6 recorder. The shotgun microphone was used to minimize the surrounding noise. The sound sources used in the simulator are shown in Table 1.

Table 1 List of sound sources used in the acoustic environment simulator.

Sound Source				
Rain	Water fountain	Adhan	People playing basketball	Horn
Birds chirping	Talking	Children playing	Fast music	Train
Cricket	Footsteps	Street performer	Slow music	Airplane
Wind	Sweeping	People playing tennis	Sundanese music	Construction
Water stream	Whistle	People jogging	Traffic	Welding

The acoustic environment simulator consisted of three hardware devices: a laptop, an audio interface (M-Audio Fast Track Ultra), and eight speakers (KRK Rockit 5). The speakers were placed around the participant with a radius of 1.5 m, as shown in Figure 2. This configuration allows 360° sound reproduction.

Figure 2 Acoustic environment simulator set-up.

4 Result and Discussion

4.1 Relationship between Expected Perception Rating with Activities

The relationship between expected semantic scale rating and type of activity was analyzed using analysis of variance (ANOVA). There was a significant relationship between the semantic scale rating 'relaxation' at $p < 0.05$ and the four different activities [$F(3,200) = 20.48$, $p = 0.00$]. Post-hoc comparison using a Tukey HSD test showed that the mean scores of the relaxation perception rating for reading ($M = 3.61$, $SD = 1.21$) and relaxing ($M = 4.10$, $SD = 1.14$) were significantly different from the scores for talking with friends ($M = 1.88$, $SD = 2.31$) and playing with children ($M = 2.00$, $SD = 2.05$). People who are engaged in reading expect a similar level of relaxation as people who are engaged in relaxing. People who are engaged in talking with friends expect the same level of relaxation as people who are engaged in playing with children.

As shown in Figure 3, people's activities need to be done in a comfortable space, as indicated by the positive rating score. However, people expect a more comfortable space for reading and relaxing compared to talking with friends and playing with children. The result of this study is consistent with the study conducted by Aletta, *et al.* [18] about urban vibrancy modeling. The pleasantness rating for spaces intended for social activities (entertainment and commercial) tended to be lower than for spaces for individual activities (green areas). The previous study also showed that the pleasantness dimension resembled the term non-disruptive. Hence, social activities tend to be associated with a lower perception of relaxation, as mentioned in Sun, *et al.* [19]

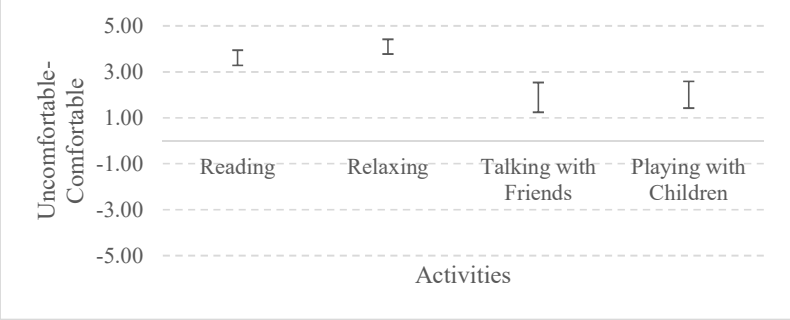

Figure 3 Semantic score rating for the relaxation perception.

The ANOVA showed that the perception rating of dynamic had a similar trend as the perception of relaxation. There was a significant relationship between the

semantic scale rating 'dynamic' at $p < 0.05$ and the different activities [$F(3,200) = 23.89$, $p = 0.00$]. Post-hoc comparison using the Tukey HSD test showed that the mean scores of the dynamic perception ratings for reading ($M = -2.29$, $SD = 2.59$) and relaxing ($M = -1.57$, $SD = 2.95$) were significantly different from the scores for talking with friends ($M = 0.75$, $SD = 2.86$) and playing with children ($M = 1.88$, $SD = 2.89$).

The dynamic perception rating for reading was not significantly different from that for relaxing. The dynamic perception rating for talking with friends was also not significantly different from that for playing with children. People who are engaged in individual activities (reading and relaxing) expect a simple environment. People who are engaged in social activities (talking with friends and playing with children) expect a varied environment, as shown in Figure 4.

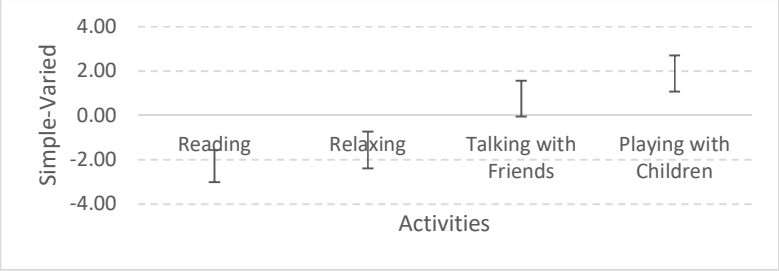

Figure 4 Semantic score rating for the dynamic perception.

The ANOVA showed that the communication perception had a similar trend as the relaxation and dynamic perceptions. There was a significant relationship between the semantic scale rating 'communication' at $p < 0.05$ and the different activities [$F(3,200) = 73.02$, $p = 0.00$]. Post-hoc comparison using the Tukey HSD test showed that the mean scores of the communication perception ratings for reading ($M = -3.14$, $SD = 2.14$) and relaxing ($M = -1.86$, $SD = 3.05$) were significantly different from those for talking with friends ($M = 1.96$, $SD = 2.43$) and playing with children ($M = 3.12$, $SD = 2.17$).

The communication perception rating for reading was not significantly different from that for relaxing. The communication perception rating for talking with friends was also not significantly different from that for playing with children. People who are engaged in individual activities (reading and relaxing) expect a private environment. People who are engaged in social activities (talking with friends and playing with children) expect a communal environment, as shown in Figure 5.

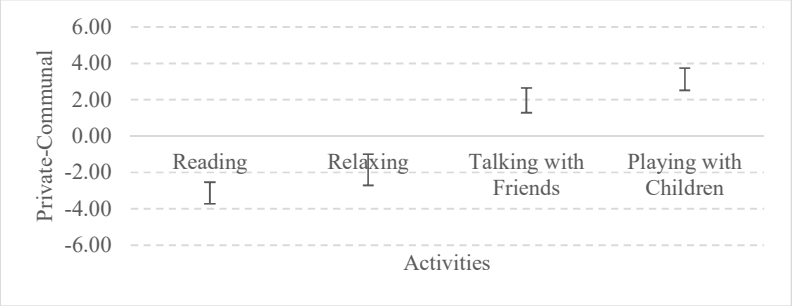

Figure 5 Semantic score rating for the perception of communication.

The expected perception in urban soundscapes is affected by the activity done in the space. Individual activities require a comfortable, simple, and private space. In contrast, social activities require a comfortable, dynamic, and communal space. Also, individual activities require a more comfortable acoustic environment compared to social activities.

4.2 Sound Source Selection of Acoustic Environment Composition Based on Activities

The expected acoustic environment for different activities was analyzed based on the sound sources selected in the acoustic environment. By understanding the sound source selection, the relationships between specific sound sources and the different activities could be determined.

The analysis was conducted using the chi-square test to understand the difference in sound source expectations related to the four different activities. The chi-square test of independence was calculated by comparing the frequencies of the sound sources selected for the four different activities. Several sound sources had a significant relationship with specific activities, as shown in Table 2.

Table 2 Chi-squared test of independence test result.

Sound source	df	N	χ2	p	Sound source	df	N	χ2	P
Rain	3	204	23.10	0.00	Street performer	3	204	21.75	0.00
Birds chirping	3	204	14.10	0.00	People playing tennis	3	204	16.43	0.00
Water stream	3	204	11.47	0.01	People jogging	3	204	22.67	0.00
People talking	3	204	57.98	0.00	People playing basketball	3	204	21.32	0.00
Footsteps	3	204	22.47	0.00	Traffic	3	204	26.71	0.01
People sweeping	3	204	10.74	0.01	Slow music	3	204	25.29	0.00
Adhan	3	204	18.55	0.00					

The sound source selections that had a significant relationship with specific activities are shown in Figure 6. Generally speaking, the sound source selections varied for different acoustic environment compositions. The sound of birds chirping was selected in acoustic environment compositions for reading, relaxing, and playing with children. The sound of children playing was chosen for social activities, especially playing with children. Slow music seemed suitable for three activities (reading, relaxing, and talking with friends), except for playing with children. Two sound sources (adhan and street performer) were selected for only one specific activity (adhan for relaxing and street performer for talking with friends). It appears that each of the four different activities needs particular sound sources. This finding is consistent with the result from Jia, *et al.* [20], who showed that the dominant characteristic of a place is determined by a combination of certain sounds rather than a dominant sound.

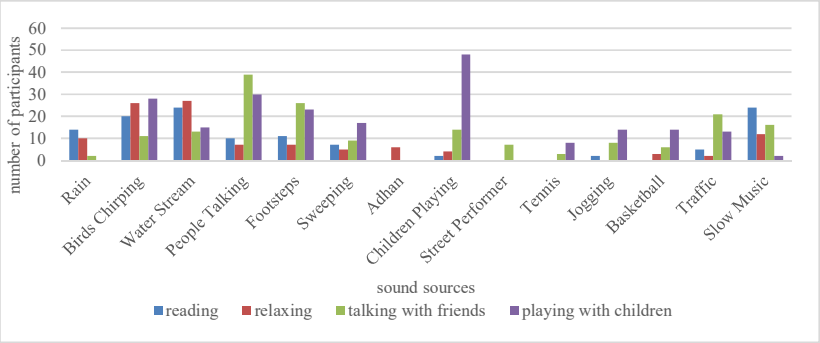

Figure 6 Selected sound sources in the acoustic environment compositions for different activities.

The sound source selections in the acoustic environment compositions for the activity of reading are shown in Figure 7. According to the acoustic environment composition data, reading requires natural sounds, such as the sound of a water stream, wind, and birds chirping. Interestingly, one of the most selected sound sources in the compositions was slow music.

This result is similar to that from a previous study, which found that natural sounds and music-related sounds have a positive effect on the modern landscape [21]. Further discussion with respondents who selected music as a sound source indicated that hearing music reminds them of a situation in a café/coffee shop. Many of the respondents in this experiment were youngsters who often spent time in coffee shops, where the main activities they engage in are reading and studying.

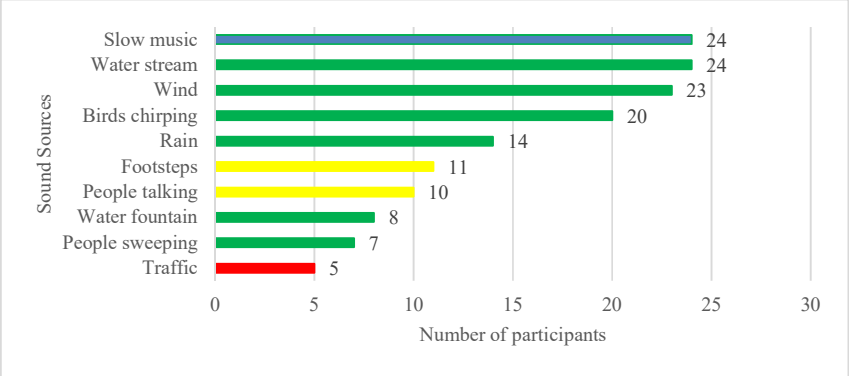

Figure 7 Selected sound sources in the acoustic environment compositions for reading (the blue bars represent music, the green bars represent natural sound sources, the yellow bars represent human activities, and the red bars represent mechanical sound sources).

People prefer to engage in relaxing activities in a place where they can enjoy natural sounds, as can be seen in Figure 8. Mechanical sound sources are not preferred for relaxing activities. Some sound sources from people's activities are also not preferred in spaces for relaxing activities.

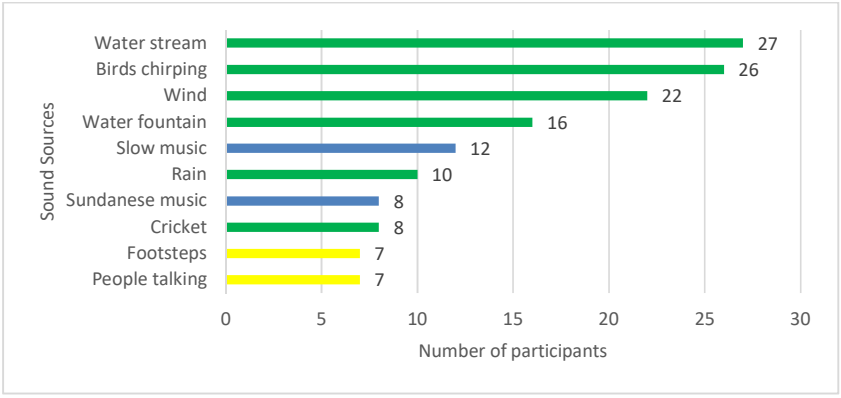

Figure 8 Selected sound sources in the acoustic environment compositions for relaxing (the blue bars represent music, the green bars represent natural sound sources, the yellow bars represent human activities, and the red bars represent mechanical sound sources).

A previous study conducted by Jia, *et al.* [20] showed that communal sounds related to talking, laughter, and other sounds from human activities are related to

social activities. The sound of children playing has a more significant relationship with people not engaged in relaxing than the sound of people talking. The result is similar to that for the activity of reading. In general, people prefer to do individual activities, such as reading and relaxing, in a place without the sound of people talking and children playing.

The activity of talking with friends needs to be done in an environment dominated by human activities, such as the sound of people talking and footsteps, as shown in Figure 9. This result indicates that people need the hubbub from the environment to be comfortable when talking with friends. Another study [22] showed that biophonic human-related sounds enhanced some land-based recreation activities, such as activities with family, sightseeing, walking, and talking.

An interesting result was shown by the selection of vehicle sounds in the ideal acoustic environment for talking with friends. Further investigation was done with participants who selected the sound of traffic. They felt that talking with friends is generally done in a busy urban area, usually located near a road. The sound of vehicles seems to represent the urban environment. This result is consistent with the study conducted by Tassia, *et al.* [17]. Another study, by Hong, *et al.* [23], showed that natural sounds, such as bird and water sounds, may reduce the perceived loudness of traffic noise. Hence, the participants chose natural sounds for the activity of talking with friends.

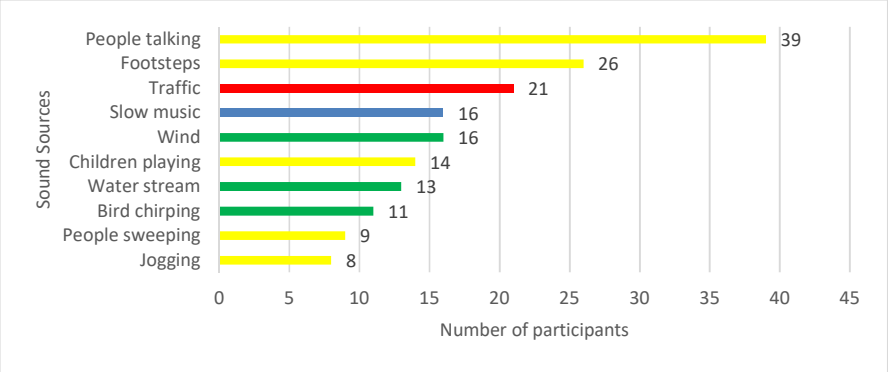

Figure 9 Selected sound sources in the acoustic environment compositions for talking with friends (the blue bars represent music, the green bars represent natural sound sources, the yellow bars represent human activities, and the red bars represent mechanical sound sources).

Natural sounds are likely not suitable for talking with friends because the respondents expect a busy urban area where natural sound sources are limited. Interesting results were found for the sound of children playing. It seems that the sound of children can disturb the activity of talking with friends and therefore tended to be avoided.

The selected sound sources for the ideal acoustic environment for playing with children are shown in Figure 10. The most selected sound source was the sound of children playing. It seems that the most suitable place to play with children is a place with other children. The other most selected sound sources were those of human activities (especially the sound of people talking and the sound of footsteps) and natural sounds (birds chirping and wind blowing).

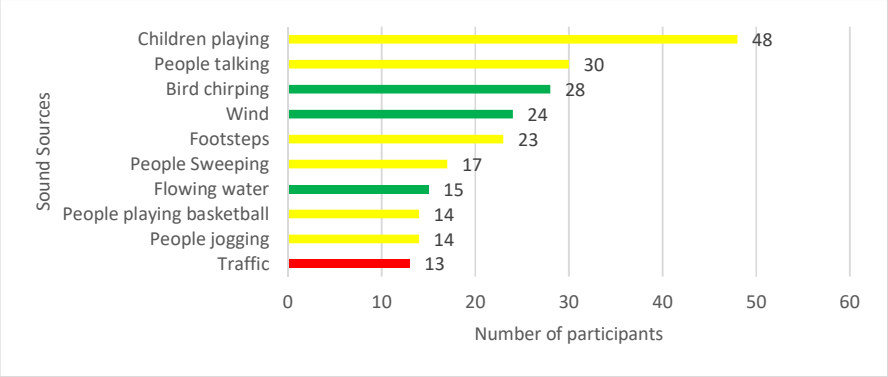

Figure 10 Selected sound sources in the acoustic environment compositions for playing with children (the blue bars represent music, the green bars represent natural sound sources, the yellow bars represent human activities, and the red bars represent mechanical sound sources).

The participants felt that a suitable space to play with children is where there are other children. The sound of children was selected by most of the participants (48 from 50 participants), which confirms the need for the presence of other children for this kind of activity.

In conclusion, different activities need to be done in environments with different acoustic characteristics. For example, people expect the sound of slow music for reading and the sound of children for playing with children. The perception expected for different activities may be similar, but the sound source expected is different for different activities.

5 Conclusion

The expected acoustic environment for different activities was analyzed using the soundscape composition approach. The experiment was implemented using an acoustic environment simulator. The expected perception, in terms of the semantic scores relaxation, dynamic, and communication, have a significant relationship with the activities done in urban spaces. Individual activities are expected to be done in a relaxed, simple, and private environment. In contrast, social activities are expected to be done in a less relaxed, more varied and communal environment. Individual activities are expected to be done in an environment dominated by natural sounds and slow music. In contrast, social activities are expected to be done in an environment dominated by sounds of human activities. Although, in general, the activities can be divided into individual and social activities, for each of the activities different sound sources are expected.

Nomenclature

df	=	degree of freedom
p	=	p-value
F	=	F-value
M	=	mean
SD	=	standard deviation
N	=	number of samples
χ^2	=	chi-square

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