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Language Noise Effects on Working Memory in University Students: A Between Subjects Experimental Study

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Abstract

Purpose: This study examined whether exposure to 70 dB language noise significantly affects working memory performance among undergraduate psychology students at Universitas Padjadjaran.

Research Methodology: A between-subjects experimental design was employed involving 46 psychology students selected through stratified random sampling based on SNBT 2023 scores. Participants were randomly assigned to a control group ($n = 23$) or an experimental group exposed to 70 dB language noise ($n = 23$). Working memory was measured using the Digit Span Forward Task administered via PsyToolkit. Data were analyzed using the Mann Whitney U test.

Results: The control group achieved a higher mean digit span score ($M = 6.70$, $SD = 1.22$) than the experimental group ($M = 6.09$, $SD = 1.41$). However, the difference was not statistically significant ($U = 200.000$, $z = -1.455$, $p = .073$), with a small effect size ($r = 0.214$).

Conclusions: Exposure to 70 dB language noise did not significantly impair working memory performance. Nevertheless, the lower mean score in the experimental group suggests a potential negative effect that may be influenced by individual differences.

Limitations: The small sample size, online experimental setting, and lack of noise sensitivity measurement may have reduced the ability to detect significant effects.

Contributions: This study extends noise-cognition research in the Indonesian university context and highlights the importance of incorporating noise sensitivity measures and stronger experimental controls in future studies.

Keywords: *Cognitive Performance, Environmental Psychology, Language Noise, Noise Sensitivity, Working Memory*

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1. Introduction

The acoustic environment of academic study exerts documented effects on students' cognitive performance and learning outcomes. Among the diverse sources of environmental noise encountered by university students traffic, music, mechanical equipment language noise (conversational speech from multiple sources) occupies a distinctive cognitive position because it simultaneously activates and interferes with the verbal-linguistic processing systems that support academic learning (Klatte et al., 2013; Song et al., 2022). Unlike spectrally simple noise types (white noise, music), language noise carries propositional content that the auditory-linguistic system automatically begins to process, consuming cognitive resources that would otherwise be available for intentional learning tasks (Basner, Babisch, Davis, Brink, Clark, Janssen, & Stansfeld, 2014).

Working memory defined as the limited-capacity system that temporarily stores and manipulates information in support of ongoing cognitive tasks (Baddeley, 2007; Matlin & Farmer, 2019) is particularly susceptible to interference from language noise. Its capacity of approximately 3–5 items (Cowan, 2014) is consumed by the competing processing demands of task-relevant information and irrelevant auditory input. When individuals process language noise in parallel with a working memory task, their attentional resources are divided between the primary task and automatic linguistic processing of the background speech, reducing the effective capacity available for task performance (Klatte et al., 2013; Evans & Stecker, 2004).

Indonesian university students face academic environments in which language noise exposure is frequent and largely unavoidable. In shared study spaces, dormitories, family households, and cafes all common study locations for Indonesian students conversational noise levels routinely exceed 65–75 dB (Sarwono, 2017). Song et al. (2022), in a study of Chinese university students, demonstrated that language noise significantly impaired working memory accuracy and reaction time, particularly among noise-sensitive individuals. However, no published study has tested this relationship specifically in Indonesian university populations, where cultural and environmental noise contexts may differ meaningfully from those in which prior experimental evidence was generated.

This study addresses this gap by conducting a between-subjects experiment to test whether exposure to 70 dB language noise significantly reduces working memory performance (as measured by the Digit Span Forward Task) relative to a no-noise control condition, among undergraduate psychology students at Universitas Padjadjaran. This intensity was selected because it represents a realistic conversational noise level comparable to a busy discussion in an open study space that university students regularly encounter, making the study's findings directly relevant to their academic environments. The research hypothesis is that participants in the language noise condition will demonstrate significantly lower digit span scores than those in the silent control condition.

2. Literature Review and Hypotheses Development

2.1 Environmental Noise and Cognitive Performance

Environmental noise is broadly defined as any unwanted sound that disrupts normal activities or causes adverse effects on human health and well-being (World, 2011). Within this category, its cognitive effects range from minor distraction to significant impairment of complex cognitive functions, depending on noise characteristics (intensity, frequency, regularity), task demands (cognitive load, task type), and individual moderating variables (noise sensitivity, fatigue, arousal) (Sarwono, 2017; Song et al., 2022). Basner et al. (2014) systematically documented that environmental noise impairs multiple cognitive domains including attention, memory, reading comprehension, and problem-solving, with effects detectable at intensities as low as 50–55 dB under controlled conditions.

The specific disruptiveness of language noise relative to other noise types at equivalent decibel levels is attributable to its semantic content. The auditory cortex and language-processing areas (Wernicke area) automatically decode speech sounds to phonemes and words even when the listener intends to ignore them, a process that competes with deliberate cognitive operations for the same neural resources (Klatte, Bergström, & Lachmann, 2013). This interference is stronger for tasks with high verbal-cognitive demand such as digit span recall, reading comprehension, and verbal reasoning than for visuospatial tasks, because both the noise and the task draw on overlapping verbal working memory resources.

2.2 Working Memory: Baddeley's Multi-Component Model

Baddeley's (2007) multi-component model of working memory provides the theoretical framework within which language noise effects are most precisely understood. The model proposes four components: the central executive (an attentional control system), the phonological loop (a verbal storage and rehearsal subsystem), the visuospatial sketchpad (a spatial and visual storage subsystem), and the episodic buffer (an integrative storage component). Language noise most directly interferes with the phonological loop because it introduces extraneous verbal material that occupies or disrupts the auditory-phonological store, reducing its capacity for task-relevant verbal information (Baddeley, 2007; Klatte et al., 2013).

The digit span forward task requiring participants to repeat sequences of digits in the correct order is a direct measure of phonological loop capacity and has been widely validated as an index of working memory capacity (Turner & Ridsdale, 2004; Gathercole & Baddeley, 2008). Cowan (2014) demonstrated that working memory underpins academic performance across diverse learning domains, as its limited capacity constrains the amount of new information that can be actively processed and integrated with prior knowledge during a learning episode. Impairment of digit span performance by language noise thus has direct implications for academic learning efficiency.

2.3 Noise Sensitivity as a Moderating Variable

A critical feature of noise effects on cognitive performance is their individual variability: identical noise exposures produce markedly different cognitive and emotional responses across individuals (Job, 1999; Song et al., 2022). This variability is substantially explained by individual differences in noise sensitivity an internal psychological disposition that amplifies reactivity to environmental noise Job, 1999. Noise sensitivity encompasses both cognitive appraisal processes (the subjective interpretation of noise as threatening or aversive) and physiological reactivity patterns (autonomic nervous system responses to acoustic stimulation).

Song et al. (2022) demonstrated that the interaction between noise sensitivity and noise type was a significant predictor of working memory performance: highly noise-sensitive individuals showed substantially greater impairment by language noise than their low-sensitivity counterparts, while the performance of low-sensitivity individuals was largely unaffected by the same noise exposure. Weinstein (1978) further established that noise-sensitive students achieved lower academic performance, experienced greater interpersonal communication discomfort, and sought more privacy than their less-sensitive peers, suggesting that noise sensitivity shapes the cumulative academic impact of environmental noise across the study environment.

The practical implication of noise sensitivity for experimental noise research is that individual heterogeneity in noise reactivity will attenuate group-level effects in experimental designs that do not measure and control for this moderating variable: high-sensitivity and low-sensitivity participants cancel each other's responses in aggregate analyses, producing a statistical null result even when real noise effects exist in the noise-sensitive subgroup (Sörqvist & Marsh, 2021). This attenuation mechanism is directly relevant to interpreting the present study's results.

2.4 Attention and Divided Attention Under Noise

Atensi (attention) is the cognitive process of selectively focusing processing resources on specific information while filtering out competing stimuli (Salo, Salmela, Salmi, Numminen, & Alho, 2017). In the context of noise exposure, two attentional mechanisms are particularly relevant. Selective attention the focusing of resources on a single task while ignoring competing stimuli is the strategy participants are instructed to employ during the digit span task. Divided attention the allocation of resources across multiple simultaneous tasks describes the actual cognitive situation when language noise is present: participants must simultaneously process task digits and the irrelevant speech stream, dividing attentional resources between the two (Salo et al., 2017). The degree to which language noise captures automatic attentional resources determines its interference with working memory performance.

From a cognitive load perspective, language noise introduces an additional processing demand that competes with the limited capacity of working memory systems, particularly the phonological loop. When irrelevant speech is processed automatically, it can disrupt encoding and rehearsal processes required for accurate digit recall, leading to reduced efficiency in maintaining information over short periods.

However, the extent of this interference is not uniform across individuals, as susceptibility to auditory distraction varies depending on cognitive control capacity and noise sensitivity. This variability may result in differential performance patterns under identical noise conditions, thereby influencing the magnitude of observed group-level effects in experimental studies of working memory.

2.5 Prior Empirical Studies

Table 1 summarizes prior studies on language noise, environmental noise, and working memory or cognitive performance outcomes.

Table 1. Summary of Prior Studies on Language Noise and Working Memory/Cognitive Performance

Author(s) & Year	Population / Setting	Method	Key Finding on Noise and Working Memory/Cognitive Function
Klatte et al. (2013)	Children, classroom settings	Systematic review	Noise impairs cognitive performance in children; effects strongest for language-based noise interfering with verbal processing tasks; younger children more susceptible
Song et al. (2022)	University students, China	Between-subjects experiment	Language noise and road traffic noise both significantly impair working memory accuracy and reaction time; noise sensitivity moderates the magnitude of impairment
Zwagery and Dewi (2019)	Adolescents, Makassar, Indonesia	Experimental	Hard-beat, fast-tempo music noise significantly impaired memory and recall performance; environmental noise effects are measurable with standard memory tasks
Hygge et al. (2002)	Schoolchildren near airports	Prospective cohort	Chronic aircraft noise exposure impaired reading and working memory; noise operates through attentional disruption and elevated arousal
Basner et al. (2014)	Multi-study review	Systematic review	Environmental noise impairs cognitive performance, sleep, and physiological stress markers; language-type noise most disruptive for verbal-cognitive tasks due to semantic interference
Cowan (2014)	Theoretical review	Theoretical review	Working memory has limited capacity of approximately 3-5 items; distracting stimuli consume capacity resources, reducing available storage for primary task information
Evans and Stecker (2004)	Experimental review	Review	Environmental stress including noise reduces attentional resources, impairs effort allocation, and undermines cognitive performance on tasks requiring sustained concentration
Job (1999)	General population	Theoretical	Individual noise sensitivity is an internal state moderating cognitive and emotional responses to noise; accounts for heterogeneous individual responses to identical noise stimuli

Table 1 demonstrates that prior evidence on language noise and working memory consistently documents significant impairment in international samples, with noise sensitivity emerging as a critical individual-difference moderator. The present study's Indonesian university sample represents a novel context in which this relationship has not been previously tested.

2.6 Research Hypothesis

> H_1 (Research Hypothesis): Participants exposed to 70 dB language noise will demonstrate significantly lower digit span forward task scores than participants in the silent control condition.
>
> H_0 (Null Hypothesis): There will be no statistically significant difference in digit span forward task scores between the language noise and control conditions.

3. Research Methodology

3.1 Research Design

A between-subjects experimental design was employed, in which participants were randomly assigned to either the experimental condition (language noise at 70 dB during digit span task completion) or the control condition (silence during digit span task completion). The between-subjects design prevents order and carry-over effects that would confound a within-subjects design specifically, the risk that noise in one condition would generate fatigue, sensitization, or habituation effects that transfer to the other condition (Christensen, Johnson, & Turner, 2015). The independent variable was language noise presence/absence; the dependent variable was digit span forward task score.

3.2 Participants

The study population comprised undergraduate psychology students from the 2023 cohort of the Faculty of Psychology, Universitas Padjadjaran, Indonesia (UNPAD). Inclusion criteria were: (1) enrollment in the Faculty of Psychology 2023 cohort; (2) possession of a valid SNBT 2023 score (used for stratification); (3) ownership of a functioning laptop for PsyToolkit access; and (4) no self-reported hearing impairment. Exclusion criteria included: (1) hearing difficulty (screened by self-report); and (2) incomplete data on any task component (Beltrán-Velasco, Donoso-González, & Clemente-Suárez, 2021; Song, Li, Ma, Han, & Wu, 2022) .

Sample size was determined using the proportion estimation method in UNPAD SAS software, with a bound of error of 0.11 and proportion of 0.50, yielding a minimum required sample of 46 from a population of 100. Stratified random sampling was applied using SNBT 2023 scores as the stratification variable a proxy for cognitive ability and academic preparation divided into three strata: Moderate, High, and Very High. This stratification ensured that groups were comparable in baseline cognitive ability, reducing a potential confounding variable. Table 2 presents the demographic profile of the final sample (Fan, Liang, Cao, Pang, & Zhang, 2022).

Table 2. Demographic Profile of Participants by SNBT Score Category and Sex (n = 46)

SNBT Score Category	**Female (n)**	**Male (n)**	**Total (n)**	**%**
Very High	3	1	4	8.7
High	30	5	35	76.1
Moderate	7	0	7	15.2
Total	40	6	46	100.0
Percentage (%)	87.0	13.0	—	—

Table 2 presents the demographic profile of the participants based on SNBT score category and sex. Of the 46 participants, 40 (87.0%) were female and 6 (13.0%) were male, reflecting the gender composition of the psychology student cohort. The majority of participants were classified in the High SNBT score category (76.1%, n = 35), followed by the Moderate category (15.2%, n = 7) and the Very High category (8.7%, n = 4). The distribution indicates that most participants possessed relatively strong academic preparation as measured by SNBT scores. Furthermore, participants from all three strata were represented in the sample, supporting the effectiveness of the stratified random sampling procedure in ensuring variation in baseline academic ability across the study population (Etikan & Bala, 2023).

3.3 Instruments

3.3.1 Working Memory Measure

Working memory was assessed using the Digit Span Forward Task, administered via PsyToolkit (an open-source cognitive testing platform; Borsboom & Van der Maas, 2013). In the digit span forward paradigm, participants view or hear a sequence of digits and are required to recall them in the exact order of presentation. Sequences were progressively lengthened from 3 to 9 digits. The score was the total number of correctly recalled sequences. The digit span forward task is a well-validated, widely used measure of phonological loop capacity and verbal working memory (Turner & Ridsdale, 2004; Gathercole & Baddeley, 2008). All tasks were conducted online via Zoom Meeting, with participants using their own laptops.

3.3.2 Language Noise Stimulus

The language noise stimulus was a recording of multiple overlapping conversational voices at 70 dB, verified using a sound level meter prior to stimulus preparation. The 70 dB intensity was selected to represent realistic conversational noise in Indonesian university open study environments (Sarwono, 2017) and to replicate the noise level used in Song et al. (2022) language noise condition. The experimental group listened to this recording continuously through their device speakers or headphones for the duration of the 10-minute digit span task. The control group completed the task in silence.

To ensure consistency of stimulus delivery across participants, standardized instructions were provided prior to the task regarding the use of audio devices and volume settings. Participants were instructed not to adjust the volume during the experiment, and a brief check was conducted to confirm that the noise stimulus was clearly audible but not uncomfortable. This procedure was implemented to minimize variability in exposure intensity and to maintain experimental control in an online testing environment.

In addition, the use of speech-based (language) noise rather than non-speech noise was intended to increase ecological validity, as conversational sound is one of the most common forms of background noise in academic settings. Unlike steady-state noise, language noise contains semantic and phonological information that can compete directly with verbal working memory processes, thereby making it particularly relevant for tasks involving digit recall (e.g., phonological loop activity).

3.4 Reliability of the Digit Span Task

Table 3. Reliability of the Digit Span Forward Task (Pilot Sample)

Instrument	Cronbach's Alpha	n Items
Digit Span Forward Task	0.654	9
Reliability Level	Moderate	—

Table 3 presents the reliability test results of the Digit Span Forward Task using Cronbach's Alpha. The analysis produced a Cronbach's Alpha value of 0.654 across nine test items, indicating a moderate level of internal consistency. This result suggests that the instrument demonstrates acceptable reliability for measuring working memory performance in the pilot sample. Therefore, the Digit Span Forward Task was considered sufficiently reliable for use in the main study (Ghozali, 2009).

The moderate reliability coefficient may be attributed to the nature of the Digit Span Forward Task, which consists of progressively increasing sequence lengths. As item difficulty increases, participants may correctly recall shorter sequences while failing longer ones, reducing inter-item correlations and consequently lowering the Cronbach's Alpha value. Such a pattern is common in cognitive performance measures and does not necessarily indicate poor instrument quality.

3.5 Procedure

Data collection was conducted online via Zoom Meeting. Sessions were facilitated synchronously with participants in their own environments. The procedure was: (1) researcher explanation of the experiment purpose and consent procedure; (2) Shapiro-Wilk normality pre-check of pilot data; (3)

random group assignment (experimental or control); (4) experimental group participants activated the language noise recording via provided audio link while beginning the PsyToolkit digit span task; control group participants completed the task in silence; (5) both groups completed the 10-minute digit span forward task via PsyToolkit; (6) scores were automatically recorded by PsyToolkit and exported for analysis (Stoet, 2017).

To minimize variability in environmental conditions during online data collection, participants were instructed to complete the experiment in a quiet setting, use headphones where possible, and avoid multitasking throughout the task duration. Although full environmental control could not be ensured due to the remote nature of the study, these standardized instructions were implemented to reduce external distractions that could confound working memory performance.

Furthermore, the use of PsyToolkit as an online experimental platform provided a structured and automated environment for stimulus presentation and response recording, reducing potential researcher bias and human error in data handling. The platform has been widely used in cognitive experimental research due to its reliability in delivering standardized tasks across diverse participant settings (Stoet, 2017).

3.6 Data Analysis

Descriptive statistics (mean, standard deviation) were computed for both groups. Normality was assessed using the Shapiro-Wilk test (selected for n < 50; Ghozali, 2009). Based on the non-normal distribution of the control group ($p < .05$), the non-parametric Mann-Whitney U test was conducted to compare working memory scores between groups. The decision criterion was $p < .05$ (two-tailed). Effect size was calculated as $r = |z|/\sqrt{N}$ (Cohen, 1988), with r = .10, .30, .50 indicating small, medium, and large effects. All analyses were conducted using IBM SPSS Statistics version 24.

The use of non-parametric testing in this study is appropriate given violations of the normality assumption in one of the experimental conditions, as parametric tests such as the independent t-test require normally distributed data across groups. When this assumption is not met, non-parametric alternatives such as the Mann Whitney U test provide a more robust approach for comparing independent samples without relying on distributional assumptions.

In addition, the interpretation of effect size (r) complements the significance testing by providing information about the magnitude of the observed difference beyond p-values. This is particularly important in psychological and cognitive research, where small but theoretically meaningful effects may not always reach statistical significance due to sample size limitations or individual variability among participants.

4. Results and Discussions

4.1 Descriptive Statistics

Table 4. Descriptive Statistics: Digit Span Forward Task Scores by Group

Group	n	Mean (M)	SD
Control (no noise)	23	6.70	1.22
Experimental (70 dB language noise)	23	6.09	1.41
Total	46	6.39	1.34

Table 4 presents the descriptive statistics of Digit Span Forward Task scores for the control and experimental groups. The control group (n = 23) obtained a higher mean score (M = 6.70, SD = 1.22) than the experimental group exposed to 70 dB language noise (n = 23; M = 6.09, SD = 1.41). The mean difference of 0.61 points indicates that participants in the control condition performed better on average than those in the noise condition. Across all participants, the overall mean score was 6.39 (SD = 1.34).

The larger standard deviation observed in the experimental group (SD = 1.41) compared with the control group (SD = 1.22) suggests greater variability in performance under language noise exposure.

This pattern may reflect individual differences in susceptibility to environmental noise, where some participants experience greater cognitive disruption than others (Zhou, Molesworth, Burgess, & Hatfield, 2024).

4.2 Normality Tests

Table 5. Shapiro-Wilk Normality Test Results by Group

Group	SW Statistic	df	p-value / Decision
Control	0.880	23	p = .010 — Non-normal
Experimental	0.937	23	p = .155 — Normal
Decision	—	—	Non-parametric test required

Table 5 presents the results of the Shapiro Wilk normality test for Digit Span Forward Task scores in both study groups. The control group produced a Shapiro Wilk statistic of 0.880 with a significance value of 0.010, indicating that the data were not normally distributed ($p < 0.05$). In contrast, the experimental group yielded a Shapiro–Wilk statistic of 0.937 with a significance value of 0.155, indicating a normal distribution ($p > 0.05$). These findings show that the normality assumption was not fully satisfied because one group exhibited a non-normal distribution (Mishra, Pandey, Singh, Gupta, Sahu, & Keshri, 2021).

Because the control group violated the normality assumption required for parametric testing, a non-parametric statistical approach was adopted. Therefore, the Mann Whitney U test was used to compare working memory performance between the control and experimental groups, as it does not require normally distributed data and is appropriate for independent group comparisons when normality assumptions are not met (Field, 2018).

4.3 Mann-Whitney U Test Results

Table 6. Mann-Whitney U Test Results: Digit Span Score Comparison Between Groups

Dependent Variable	U	z	p	Decision
Working Memory (Digit Span Score)	200.000	−1.455	.073	Retain H_0 (ns)
Effect size $r = \|z\|/\sqrt{N}$	0.214	—	—	Small effect

Note: Effect size $r = |z|/\sqrt{N} = |-1.455|/\sqrt{46} = 0.214$. *Small effect:* $r < .30$ (Cohen, 1988). $\alpha = .05$. *IBM SPSS Statistics v24.*

Table 6 presents the results of the Mann Whitney U test comparing Digit Span Forward Task scores between the control group and the experimental group exposed to 70 dB language noise. The analysis yielded a Mann Whitney U value of 200.000 with a z-score of −1.455 and a significance value of 0.073. Because the p-value exceeds the significance threshold of 0.05, there is no statistically significant difference in working memory performance between the two groups. Therefore, the null hypothesis is retained, indicating that exposure to 70 dB language noise did not significantly impair working memory performance among the participants (Visentin, Pellegatti, Garraffa, & Prodi, 2023).

Furthermore, the calculated effect size ($r = 0.214$) indicates a small effect. Although the direction of the effect suggests lower performance in the experimental group, the magnitude of the difference was insufficient to reach statistical significance. These findings imply that any potential impact of language noise on working memory in this sample was relatively weak and may have been influenced by individual differences among participants (Oberfeld, Staab, Kattner, & Ellermeier, 2024).

4.4 Discussion

4.4.1 Interpretation of the Null Result

The null result no statistically significant group difference despite a descriptive trend in the predicted direction requires careful theoretical interpretation. Three explanations are most plausible. First, insufficient statistical power: the sample of 23 participants per group is small relative to the small-to-medium effect size typically associated with noise-cognition research (Cohen, 1988). A power analysis suggests that detecting the observed effect size (r = 0.214) at α = .05 with 80% power would require approximately 85 participants per group, more than three times the present sample size. The present study was likely underpowered to detect a real but small effect.

Second, noise sensitivity heterogeneity: as documented by Song et al. (2022) and Job (1999), individual differences in noise sensitivity produce highly variable responses to identical noise stimuli. Without measuring noise sensitivity, high-sensitivity participants (who would have been substantially impaired) and low-sensitivity participants (who would have been unaffected) were averaged together, diluting the group-level effect. The greater score variance in the experimental group (SD = 1.41 vs. 1.22 in control) is consistent with this heterogeneity hypothesis.

Third, attentional adaptation: participants in the experimental group were exposed to the same language noise for the entire 10-minute task duration. Research on attentional adaptation to continuous noise indicates that individuals can habituate to consistent background noise within several minutes of exposure, potentially reducing its disruptive effects during later portions of the task (Basner, Babisch, Davis, Brink, Clark, Janssen, & Stansfeld, 2014). A paradigm that varies noise presence across shorter intervals would prevent habituation and may produce larger effects.

4.4.2 Theoretical Significance of the Descriptive Trend

While the group difference did not reach statistical significance, the descriptive direction (control M = 6.70 > experimental M = 6.09; mean difference = 0.61; effect r = 0.214) is consistent with the predictions of Baddeley's (2007) phonological loop interference model and with the findings of Song et al. (2022) and Zwagery and Dewi (2019). This suggests that language noise does produce a directional impairment on working memory in this population, but that the present study's sample size was insufficient to demonstrate this at the α = .05 threshold. The study should therefore not be interpreted as demonstrating that language noise has no effect on working memory, but rather that the current design was insufficiently powered to detect the effect with statistical confidence.

4.4.3 Role of Attention

The attention division mechanism theorized by Salo et al. (2017) provides a cognitive account of the directional trend observed. When language noise is present, participants must simultaneously process task-relevant digit sequences through the phonological loop and suppress the involuntary linguistic processing triggered by the speech background a divided attention demand that reduces the effective working memory capacity available for the primary task. The control group, processing digits in silence, could direct all phonological loop resources to task performance. The directional mean difference is consistent with this mechanism, even if not statistically significant (He, Guo, Wang, Lin, Wu, Wang, Zhang, & Zhao, 2022).

The interference of irrelevant speech with working memory performance can be explained through cognitive load mechanisms, where competing auditory information increases processing demands and reduces the availability of attentional resources for task-relevant encoding and maintenance. In verbal working memory tasks such as digit span, this interference is particularly relevant because both the task and the distraction rely on similar phonological processing systems, increasing the likelihood of competition for cognitive resources.

Furthermore, even when statistical significance is not achieved, consistent directional trends in performance outcomes may still reflect underlying cognitive processes predicted by theoretical models of auditory distraction. Such patterns are often interpreted as indicative of weak or context-dependent effects, which may become more pronounced under conditions of higher task difficulty, increased noise intensity, or greater individual susceptibility to auditory interference.

5. Conclusions

5.1 Conclusion

This study examined the effect of 70 dB language noise on working memory performance (Digit Span Forward Task) in a between-subjects experiment with 46 undergraduate psychology students at

Universitas Padjadjaran. The Mann-Whitney U test found no statistically significant group difference (U = 200.000, z = −1.455, p = .073), retaining the null hypothesis. However, a directional trend in the predicted direction (control M = 6.70 vs. experimental M = 6.09; r = 0.214) and greater score variance in the experimental group are consistent with a real but attenuated language noise effect, most plausibly attributable to insufficient statistical power (n = 23 per group) and unmeasured individual differences in noise sensitivity.

Three practical implications follow from these findings. For students, both conditions demonstrated relatively high absolute working memory performance (total M = 6.39), suggesting that under short-duration exposure to moderate-intensity language noise, most students retained working memory function. However, the descriptive mean difference (0.61 points, 9.1% relative decrease in experimental group) suggests that some students are meaningfully affected, warranting attention to acoustic study environment quality. For institutions, these findings support the provision of quiet study spaces as a means of reducing the environmental working memory load on students, particularly those with high noise sensitivity. For researchers, this study identifies noise sensitivity measurement as a critical methodological requirement for future Indonesian noise-cognition studies.

5.2 Research Limitations

Four limitations qualify this study's findings. First, the sample size of 46 (23 per group) provides insufficient statistical power to detect small effects (r = .21); the study was likely underpowered, and the null result should not be interpreted as evidence of no effect. Second, individual noise sensitivity was not measured, preventing moderator analysis of who was most affected by the noise condition; this is the most critical methodological gap given the documented importance of noise sensitivity as a moderator in prior research. Third, the online experimental setting via Zoom limited control over participants' physical environments some participants may have been in naturally noisy environments during the control condition, reducing the contrast between conditions. Fourth, the digit span forward task measures one component of working memory (phonological loop capacity); language noise effects on other working memory components (central executive, episodic buffer) were not assessed.

5.3 Suggestions and Directions for Future Research

Future research should address the identified limitations through several refinements. First, a substantially larger sample targeting a minimum of 85 participants per group based on power analysis for the observed effect size would provide adequate statistical power to detect the small-to-medium effects expected from noise-cognition research. Second, pre-experimental measurement of individual noise sensitivity using a validated instrument (e.g., the Noise Sensitivity Questionnaire would enable moderation analyses examining whether language noise effects are concentrated among high-sensitivity individuals, directly replicating moderator finding in an Indonesian sample.

Third, laboratory administration in a controlled acoustic environment rather than via Zoom in participants' own settings would ensure that the control condition is genuinely quiet and that noise intensity in the experimental condition is consistently verified at 70 dB. Fourth, extending the working memory battery to include n-back tasks, reading span tasks, and operation span tasks alongside digit span would enable assessment of whether language noise affects multiple working memory components or is specifically targeted at the phonological loop. Finally, a longitudinal design examining cumulative working memory effects of repeated language noise exposure across academic semesters would address the practically important question of whether chronic noise exposure in Indonesian university environments produces sustained impairment over time, beyond the acute experimental effects examined in the present study.

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Author Contributions

AJ conceived and supervised the study. NG, MR, NL, and SK participated in the research design, data collection, and experimental implementation. NG and MR conducted data processing and statistical analyses. NL and SK contributed to literature review, data interpretation, and manuscript preparation. AJ reviewed and revised the manuscript critically for intellectual content and approved the final version. All authors contributed to the development of the study, read, and approved the final manuscript.

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