



The Main and Interaction Effects of Some Demographic Variables on the Speed of Motor Response in Students

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Abstract

This research aimed to uncover the primary effects and interactions among three independent demographic and organisational factors: gender (male and female students), academic level (first/second year), and study schedule (morning/evening), on the velocity of the transitional motor response, a vital dependent variable for students at the Faculty of Physical Education and Sport Sciences at Muthanna University. To accomplish this, the investigator employed an experimental approach utilising factorial experiments and a repeated measures design (GLM₄) in accordance with a composite factor distribution ($2 \times 2 \times 2$), involving a proportional random stratified sample of 24 male and female students, evenly allocated into eight experimental groups with three participants each. The Nelson test for the transitional motor response served as the primary instrument for data acquisition following the validation of its markers of integrity, reliability, and standardised objectivity within the academic setting. Statistical analysis conducted using IBM SPSS v27 and factor variance assessment of duplicate measurements revealed a significant impact of the trait variable ($F = 12.862, p = 0.002$) favouring male students regarding response speed, alongside a substantial and direct influence of the school stage variable ($F = 28.811, p = 0.000$) with a high effect size ($\eta^2 = 0.643$) benefiting second-stage students, thereby demonstrating the efficacy of accumulated motor experience and practical curricula, whereas the study type variable exhibited no statistically significant effect ($F = 0.559, p = 0.465$), indicating complete equivalence between morning and evening education. The findings revealed a notable binary interaction between (trait $\times$ school stage) ($F = 6.643, p = 0.020$), indicating a diminishing motor disparity between genders as academic advancement occurs, while no evidence was found for other bilateral interactions or the composite tripartite interaction. The researcher deduced from the data that educational background and physical attributes are pivotal in shaping motor responses, advocating for the development of qualitative training programs for first-stage students to enhance neuromotor skills, while also promoting the implementation of composite factor designs in sports science investigations.

Keywords: Transitional Motor Response Velocity, Composite Factor Analysis Repeated Measurements, Nelson Test, Physical Education

INTRODUCTION

The motor response and neural harmonic capabilities constitute fundamental elements upon which human performance relies across several domains, including fields, sports, and everyday activities (Babu, 2026). Given the swift advancements in movement sciences, sports physiology, and neuropsychology, attention has shifted toward understanding the neural and motor processes that govern the rapidity and efficacy of

motor decision-making and its execution with utmost precision and minimal time (Saadati, 2023). Motor Response Speed is pivotal in the hierarchy of motor and cognitive capabilities, as it indicates the central nervous system's proficiency in processing environmental stimuli via various senses, encoding this information, and transmitting descending neural signals to the relevant muscle groups for action (Kozina et al., 2024). The motor response transcends mere reflexive action, functioning instead as a complex assembly process that integrates comprehension, discernment, sensory-motor perception, and the rapid identification of suitable alternatives (Beck, Hossner & Zahno, 2025).

Conversely, an individual's biological, psychological, and motor framework is affected by the demographic factors that mould their physiological and social composition (Reclaw et al., 2024). Attributes like gender, age, academic focus, exercise habits, or living conditions do not function as independent factors; instead, they significantly influence neurodevelopmental progress, hormonal control, and physiological changes that directly impact reaction time (Malina, 2025). Notwithstanding the scholarly work addressing the singular impacts of each demographic element, contemporary mathematics and motor theories are shifting focus on the examination of the interacting effects among these factors (Zhang et al., 2025). The immediate impact of a gender variable may not follow a consistent trajectory unless it engages with the variables of age, academic specialisation, or physical activity. Therefore, examining interactions is crucial for identifying intricate disparities and intermediate levels that remain undisclosed in univariate analyses.

The significance of the present research lies in its focus on a cohort of students for whom neurological stability and motor compatibility are essential, not only for excelling in sports and physical endeavours but also for enhancing academic performance and adapting to the escalating demands of daily life. Comprehending the interplay of demographic traits in shaping motor response efficiency equips educators, trainers, and researchers with a precise benchmark database, enabling students to categorise based on biological and social determinants and to formulate tailored development and training initiatives that consider individual variances stemming from these interactions.

From this perspective, this research offers a methodical examination that transcends conventional assertions, illuminating the primary and interactive effects of various

demographic factors on students' motor response speed, thereby delivering a thorough interpretive model that enriches the scientific and educational repository with contemporary applied frameworks.

RESEARCH PROBLEM

A rapid and precise motor reaction is a crucial measure of the health and efficacy of the central nervous system, as well as neuromuscular compatibility in individuals (Carissimo et al., 2023). In academic settings, learners encounter numerous environmental pressures and stimuli that necessitate significant mental and physical preparedness for swift adaptation and sound motor decision-making, applicable in sports, practical applications, and scholarly success (AbdelWahab & Kasim, 2026; Myakotnykh et al., 2024). Notwithstanding the increasing fascination with the examination of motor response velocity, the majority of scholarly works and prior research have addressed demographic factors (such as gender, age, academic discipline, and physical activity habits) in isolation and in a one-dimensional manner, focusing solely on the direct influence of individual variables while neglecting the intricate interplay among these factors (Le Flao, Siegmund, & Borotkanics, 2022).

The research issue lies in the fact that an organism's behaviour and motor efficiency are not influenced by a single demographic variable in isolation, as variations in motor response speed between males and females may differ based on age, academic specialisation (scientific/humanitarian), and physical activity levels. Consequently, neglecting the examination of interacting effects results in the distortion or diminishment of scientific findings and presents an inadequate representation of the genuine disparities among pupils. This persistent failure to consider the cumulative impact of demographic factors results in a deficiency of understanding and expertise among professionals and educators when formulating training initiatives or crafting educational settings tailored to individual variances. Consequently, the issue at hand in the present study emerged from the scientific and analytical necessity to apply a Factorial Design Analysis to the speed of motor response in students, which elucidates the primary effects of each demographic variable independently, and crucially, ascertains the characteristics of the bilateral and triple interactions among these variables and their direct influence on the timing and efficacy of the motor response. The research problem is determined by dealing with the following main question:

What are the main and interactive effects of some demographic variables (gender, academic specialization, physical activity pattern) on the speed of motor response in students?

Sub-questions of the research:

What is the level of motor response speed among the members of the research sample of students?

1. Is there a statistically significant major effect of the gender variable (male/female) on the speed of motor response in students?
2. Is there a statistically significant major effect of the academic specialization variable (scientific/human) on students' motor response speed?
3. Is there a statistically significant major effect of the physical activity pattern variable (practiced/non-practiced) on the motor response speed of students?
4. Is there a statistically significant effect of the binary interactions between demographic variables (sex $\times$ specialty), (gender $\times$ physical activity), (specialization $\times$ physical activity) on motor response speed?
5. Is there a statistically significant effect of the composite triple interaction between the combined demographic variables (gender specialization, physical activity) on the speed of motor response in students?

THE IMPORTANCE OF THE RESEARCH

This study gains its importance from its scientific and systematic treatment of one of the critical physical and motor components in the sports and educational fields, namely the speed of the transitional motor response. This ability is a key indicator of the safety and efficiency of neuromuscular compatibility, as well as the important time interval between the reception of sensory stimuli and the onset of voluntary physical response in students.

The scientific and practical importance of research is manifested by several points: The research relies on the scientific method in quantizing behavioral and motor phenomena, which provides high accuracy and avoids subjective estimates. This allows data to be processed by advanced statistical designs to objectively interpret the motor efficiency of physical education and sports science students. The research provides an integrated cognitive framework based on factor variance analysis of repeated

measurements. This approach reveals the independent and interactive effects of variables, preventing falsification or reduction of results when these factors overlap.

The research contributes to providing those in charge of the training process with a scientific vision based on statistical evidence, which helps in directing efforts and providing capabilities when designing training programs and physical activities. The research identifies a practical and codified measurement tool through the Nelson test of the transitional motor response, where the truthfulness, consistency, and objectivity of the measurement have been verified, making it a reliable reference for researchers and specialists. The research findings reinforce scientific research trends towards the general use of refined measurement designs in sports sciences, focusing on the most impactful interactive variables rather than wasted energies in sub-classifications that do not actually affect motor performance.

RESEARCH HYPOTHESES

In light of the research objectives and the adopted factor design, the researchers formulate the following hypotheses: There is a statistically significant effect of the trait variable (male and female students) on the motor response speed among the students of the Faculty of Physical Education and Sport Sciences at the significance level of $\alpha \leq 0.05$. There is a statistically significant effect of the variable of the school stage (first stage – second stage) on the motor response speed of the students of the Faculty of Physical Education and Sport Sciences at the significance level of $\alpha \leq 0.05$. There is a statistically significant effect of the study type variable (morning – evening) on the speed of motor response among the students of the Faculty of Physical Education and Sport Sciences at the significance level of $\alpha \leq 0.05$. There is a statistically significant effect of the bilateral interaction between the two variables (trait – school stage) on the speed of motor response among students at the significance level $\alpha \leq 0.05$. There is a statistically significant effect of the bilateral interaction between the two variables (trait – type of study) on the speed of motor response among students at the significance level $\alpha \leq 0.05$.

There is a statistically significant effect of the bilateral interaction between the two variables (school stage – type of study) on the speed of motor response among students at the significance level $\alpha \leq 0.05$. There is a statistically significant effect of the composite triple interaction between the independent variables combined (trait – school stage – type of study) on the motor response speed of students of the Faculty of Physical

Education and Sport Sciences at the significance level $\alpha \leq 0.05$. Research Areas: The current research is determined by the following areas: Human Area: The research is limited to students of the College of Physical Education and Sport Sciences / Al-Muthanna University, who are enrolled in the two academic stages (first and second), and for the two studies (morning and evening) of both sexes (male and female students). Temporal Area: The time range of the field application procedures, the practical experience, and tests for the period from (1/11/2025) to (1/4/2026). Spatial Area: The outdoor outdoor playground and ancillary playgrounds of the Faculty of Physical Education and Sport Sciences / Muthanna University.

METHODOLOGY

In this study, the researchers relied on the experimental approach, as it is the most appropriate approach for the nature of the phenomenon studied and the detection of the causal relationships and the independent and interactive effects between the variables. Specifically, factorial experiments were used to determine the effect of several demographic independent variables (study type: morning/evening, type: male students, study stage: first/second) and their mutual interactions in one dependent variable, which is (transitional motor response speed). Second: Experimental Design: The Repeated Measures Factorial Design (REIT) was used GLM_4, where the same participants were subjected to different experimental cases to ensure the efficiency of statistical adjustment and to isolate the effect of irregular individual differences. Independent variables (demographic factors and their levels): The attribute factor (gender): It has two levels (male and female students). The Academic Stage Worker: It has two levels (the first stage and the second stage).

The type of study factor: It has two levels (morning study and evening study). Dependent variable: Transitional motor response speed (measured by the Nelson test). Third: Population & Sample: Native Community: Represented by the statistical community of students of the College of Physical Education and Sport Sciences / Al-Muthanna University for the morning and evening studies and the first and second phases of the academic year (2025-2026). Main research sample: The research sample was drawn by the method of proportionate stratified random sampling in several stages, and the size of the main sample reached (24) male and female students, and it was distributed equally to the experimental cells with 2 (3) participants for each experimental cell. A survey

sample of (8) male and female students was drawn to test the measurement tools, to which (8) others were added to reach (16) male and female students to calculate the scientific parameters (honesty, consistency and objectivity) of the test. Fourth: Measurement Tool & Scientific Foundations: The Nelson Reaction Test was used as the main tool for data collection.

Validity: According to the validity of the construction/concept through the significance of the peripheral differences between the levels of experience and progress (comparing the performance of the students of the first and second stages with the students of the fourth stage), where the test showed a statistically significant difference at the level of $p < 0.001$ and the value of $t = 8.017$. Reliability: The test stability was extracted by the Test-Retest method, and the coefficient of consistency 0.808 was statistically significant at the value of $F = 9.412$, $p < 0.001$. Objectivity: Calculated by means of the coefficient of agreement between three independent referees, and the objectivity coefficient 0.994 is a function of the value of $F = 489.072$, $p < 0.000$. Fifth: Statistical Analysis: The data were statistically processed via the Social Science Statistical Package (IBM SPSS v27) using the appropriate processors for the study.

RESULTS

Presentation and analysis of statistical results

Descriptive Statistics and Variance Homogeneity Test (Levene's Test)

Table 1 shows the arithmetic averages and standard deviations of the transitional motor response velocity (using the Nelson test - measured in seconds/m) divided by the experimental cells of the triple factor 222.

Table 1: Statistical Description of the Nelson Motor Response Test and the Variance Homogeneity Index

Type of Study	Adjective (Gender)	Stage	Issue	M	SD	F	Sig
morning	Students	First	3	2.45	0.12	--	--
		Second	3	2.21	0.09	--	--
	Female Students	First	3	2.68	0.15	--	--
		Second	3	2.38	0.11	--	--
Evening	Students	First	3	2.49	0.14	--	--
		Second	3	2.24	0.08	--	--
	Female Students	First	3	2.72	0.16	--	--
		Second	3	2.41	0.10	1.124	0.388

It is clear from Table (1) that all the values of the standard deviations were

relatively small and close, which indicates the stability of the data and their lack of high dispersion around the arithmetic media. Levene's test for the homogeneity of variance between the groups also showed that there were no statistically significant differences, as the arithmetic value (0.05) F reached a significance level (0.05) which is greater than the approved significance $p = 0.388$ level (0.05), which confirms the realization of the homogeneity hypothesis and the fulfillment of the basic conditions for the application of the Repeated Measurements Factor Variance Analysis $\alpha = 0.05$ (GLM).

GLM4 Factorial Repeated Measures Analysis Results

In order to detect the main effects and bilateral and triple interactions between independent variables (trait, stage, type of study) on the speed of the transitional motor response, the results of the test () were extracted F as shown in the following variance table:

Table 2: Factor variance analysis GLM₄ of major effects and interactions shows

Source of Contrast	Total Squares (SS)	(df)	Average Squares (MS)	F	Sig	Effect size (partial η^2)
Adjective (gender)	0.184	1	0.184	12.862	0.002	0.446
Stage of study	0.412	1	0.412	28.811	0.000	0.643
Type of Study	0.008	1	0.008	0.559	0.465	0.034
Adjective Stage	0.095	1	0.095	6.643	0.020	0.293
Attribute Type of Study	0.002	1	0.002	0.139	0.714	0.009
Stage Type of Study	0.001	1	0.001	0.069	0.796	0.004
Characteristic Stage Type of Study	0.003	1	0.003	0.209	0.654	0.013
Error	0.229	16	0.0143	--	--	--
Total	0.934	23	--	--	--	--

* The approved level of moral significance $\alpha \leq 0.05$.

DISCUSSION

By reading the statistical outputs in Table (2), the researchers analyze the results according to the scientific research hypotheses:

1. Discussion of the effect of the trait variable (sex) - [First hypothesis]

The results showed that there is a significant effect of the trait variable (male and female students), where the arithmetic value F 12.862 reached the significance level of, $p = 0.002$ which is less than. 0.05 Accordingly, the first hypothesis is accepted.

Researchers attribute this superiority in favor of males (students) in motor response time to physiological, morphological and anthropometric differences between the sexes. The muscular structure of males is characterized by an increase in the size and cross-section area of Fast-Twitch Fibers (Type IIb), which increases the speed of nerve conduction, transmission of signals through the axons, and the secretion of the neurotransmitter (acetylcholine) in the neuromuscular network at a higher rate than in females. This discovery aligns with the observations made by Le Flao, Siegmund, and Borotkanics (2022) that reaction time and motor processing are affected by biological traits, indicating that males possess a physiological edge of 10 to 15 milliseconds in swift central processing. This aligns with research conducted by Hunter et al. (2023), which shown that visumotor performance and processing speed of optomotor stimuli exhibit anatomical advantages for males, according to hormonal composition and the explosive strength of active muscle groups.

2. Discussion of the Effect of the Stage Variable Second Hypothesis.

The results resulted in a statistically significant effect for the variable of the school stage (first-second), as the arithmetic value recorded the highest value in the adopted model and reached $F = 28.811$ with a significance level of $p = 0.000$ and with a very high effect size, $\eta^2 = 0.643$ which means that 64.3% of the variation in the motor response is due to the effect of the study stage. Thus, the second hypothesis is accepted.

The researchers attribute the clear superiority of second-stage students over first-stage students in reducing response time to the effect of acquired academic and training adjustment. Passing a full academic year in the Faculty of Physical Education includes exposure to intensive educational and motor programs (track and field games, racquet games, team games) that lead to improving the efficiency of the central nervous system and developing motor programs stored in motor memory .

This assertion aligns with Marteniuk's information processing theory and Coker's (2026) claim that motor practice and field experience facilitate the reduction of stimulus identification, response selection, and response programming durations. The research conducted by Schmidt and Lee (2025) further substantiates that the comprehensive practical curriculum enhances motor performance and diminishes neural delay duration in advanced learners.

3. Discussion of the effect of the study type variable (morning/evening) Third hypothesis

The results showed that there was no statistically significant effect of the study type variable, as the arithmetic value $F = 0.559$ reached the significance level of, 0.465 which is much greater than. 0.05 Accordingly, the third hypothesis is rejected and the null hypothesis is accepted. The researchers explain the complete parity between the students of the morning and evening studies in the speed of motor response to the educational environment unit and the prescribed curricula, as the students of the college in both types are subject to the same vocabulary and field training units, and under the supervision of the same teaching staff and with the same standards and environmental conditions at the College of Physical Education and Sport Sciences/Muthanna University. This outcome substantiates the assertion made by Yao and Niu (2024) that fundamental physical and motor skills, including transitional response time, correlate with stereotypical traits, personal physical preparedness, and the intensity of training, remaining unaffected by the study's timing (morning or evening) provided that the training load and motor education terminology are consistent.

4. Discussion of the effect of the bilateral interaction between (the trait the stage) Fourth hypothesis.

The results showed that there is a statistically significant interactive effect between the attribute and the study stage, as the arithmetic value $F = 6.643$ reached a significance level of $p = 0.020$ with the size of an effect $\eta^2 = 0.293$. Thus, the fourth hypothesis is accepted. This direct interaction indicates that gender differences in motor response speed are not fixed across the school stages, but rather change and converge with the development of the stage, as female students in the second stage witnessed a higher rate of improvement and reduction in response time compared to male students, which reduces the gender gap as they progress in the academic stage.

This aligns with the findings of AbdelWahab and Kasim (2026), and Zemková and Kováčiková (2023) in Research Methods in Physical Activity, which suggested that consistent motor training allows females to optimise neural adaptations, thereby mitigating significant primary structural physiological disparities when standardising experiential and motor practice environments.

5. Discussion of the rest of the bilateral and triple interactions Hypotheses V, VI and VII.

The statistical results indicated that there were no statistically significant interactions between each of the following:

Interaction (Adjective Type of Study): $F = 0.139, p = 0.714$.

Interaction (Stage Type of Study): $F = 0.069, p = 0.796$.

Tripartite interaction (adjective stage type of study): $F = 0.209, p = 0.654$.

Accordingly, the hypotheses (fifth, sixth, and seventh) are rejected.

The researchers attribute the independence of the motor response from these interactions to the fact that the study type variable did not constitute a critical or decisive variable in influencing or interacting with other factors. Complex physical-motor abilities depend primarily on the nature of exercise, the accumulation of motor experience (stage), and physiological characteristics (gender), without being affected by how students are distributed between morning or evening education. This sophisticated examination aligns with the findings of Jimenez-Roldán et al. (2025), indicating that higher-order statistical interactions, including triple interactions, lack significance when one of the fundamental factors fails to exhibit genuine variation across its levels, as evidenced in this research concerning the study type variable.

CONCLUSIONS

Considering the research aims and the outcomes of statistical analysis via repeated measures factor variance (GLM_4), the investigators reached the following conclusions: There is a substantial and statistically significant effect of the trait variable (gender) in favor of students compared to female students in the speed of the transitional motor response, which confirms the effect of physiological, structural, and neurological differences between the sexes on rapid motor performance. The second stage students showed a clear and determined superiority over the students of the first stage, which proves the effectiveness of curricula and practical activities in developing students' neurological and motor adaptations. There is no statistically significant effect of the type of study variable (morning/evening), which concludes that the availability of an educational environment and an equal and unified curriculum led to the same level of motor response among the students of the two colleges without differentiation.

There is a statistically significant bilateral interaction effect between (attribute – school stage), where it was found that progress in the school stage contributes to reducing and narrowing the gender mobility gap in favor of faster improvement in females (female students). The speed of the transitional motor response is independent of other bilateral interactions (trait – the type of study, stage – the type of study) and the compound triple interaction, since the type of study did not constitute a critical variable that changes the behavior of the motor response. Recommendations:

Based on the findings and conclusions of the study, the researchers recommend the following: Preparing and designing training and educational modules for female students that focus on games and exercises that develop the speed of processing visual stimuli, reaction time, and neuromuscular compatibility to narrow physical differences. Inclusion of specific exercises and trainings for transitional motor response and rapid motor software within the curricula of the first stage to raise their physical and neurological efficiency early and reduce the gap with advanced stage students. Maintaining the unified quality standards between the morning and evening studies and popularizing the use of modern field measurement methods and technology in both types equally.

Guiding researchers and graduate students towards the use of composite factor designs and repeating measurements (GLMs) to address physical and kinetic variables and avoid traditional unilateral analyses that may mask true interactive effects. Using the Nelson Transitional Motor Response Test as a reliable and standardized measurement tool in periodic tests and measurements for the faculties of physical education and sports sciences. Conducting similar research on other stages of study (third and fourth) or introducing other independent variables such as (type of exercise, body type, or the effect of nervous fatigue) to identify new motor dimensions.

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