Peran Kecemasan Matematika Terhadap Efisiensi Pemrosesan Approximate Number System (ANS):
Studi EEG-ERP (P2p)
Muh. Nur Haq I. S. Mannesa, Dra. Sri Kusrohmaniah, M.Si., Ph.D., Psikolog
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Peran Kecemasan Matematika Terhadap Efisiensi Pemrosesan *Approximate Number System* (ANS): Studi EEG-ERP (P2p)

Muh. Nur Haq I. S. Mannesa[1], Sri Kusrohmaniah[2]
[1,2] Fakultas Psikologi Universitas Gadjah Mada
e-mail: *[1]muhnurhaqismannesa@mail.ugm.ac.id, [2]koes_psi@ugm.ac.id

Abstract. Mathematical anxiety (MA) is a negative emotional response hypothesized to be associated with the processing efficiency of the Approximate Number System (ANS), the foundational neurocognitive system for non-symbolic quantity estimation. This study examined the role of MA in ANS processing efficiency through a multi-level approach integrating behavioral and neurophysiological indicators. Participants (N = 32, high school students aged 15 to 18 years) were classified into High Math Anxiety (HMA, n = 16) and Low Math Anxiety (LMA, n = 16) groups based on Abbreviated Math Anxiety Scale (AMAS) scores using an extreme-group strategy. ANS performance was assessed using a Dot Comparison Task (DCT) with varying numerical ratios (easy, medium, hard) while 32-channel EEG was recorded. Mixed-design ANOVAs were applied to accuracy, reaction time, and P2p amplitude (200 to 300 ms). No significant behavioral differences emerged between HMA and LMA on accuracy, reaction time, or Weber fraction, and the main effect of Group on P2p amplitude was likewise non-significant. A larger P2p peak amplitude in HMA (d = 0.77) did not survive correction for multiple comparisons, and amplification on the hard ratio condition was near-significant (d = 0.69). Main effects of Block were significant at both behavioral and neural levels, indicating paradigm sensitivity. This behavioral-neural dissociation suggests equivalent performance accompanied by a heavier neural load in HMA, consistent with Attentional Control Theory. The findings provide preliminary neurophysiological evidence in Indonesia on the association between MA and ANS and inform the development of neurocognitive-based interventions, with statistical-power and design limitations that warrant replication.

Keywords: mathematical anxiety; approximate number system; P2p; electroencephalography; Attentional Control Theory

Abstrak. Kecemasan matematika (Mathematical Anxiety/MA) merupakan respons emosional negatif yang diduga berkaitan dengan efisiensi pemrosesan Approximate Number System (ANS), yaitu sistem neurokognitif dasar untuk estimasi kuantitas non-simbolik. Penelitian ini mengkaji peran MA terhadap efisiensi pemrosesan ANS melalui pendekatan multi-level yang mengintegrasikan indikator behavioral dan neurofisiologis. Partisipan (N = 32, siswa Sekolah Menengah Atas berusia 15 sd 18 tahun) dikelompokkan menjadi High Math Anxiety (HMA, n = 16) dan Low Math Anxiety (LMA, n = 16) berdasarkan skor Abbreviated Math Anxiety Scale (AMAS) melalui strategi extreme group. Pengukuran ANS menggunakan Dot Comparison Task (DCT) dengan variasi rasio numerik (mudah, sedang, sulit) dan perekaman EEG 32 kanal. ANOVA mixed-design diterapkan pada akurasi, waktu reaksi, dan amplitudo komponen P2p (200 sd 300 ms). Tidak terdapat perbedaan behavioral yang signifikan antara HMA dan LMA pada akurasi, waktu reaksi, maupun Weber fraction, dan efek utama Kelompok pada amplitudo

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P2p juga tidak signifikan. Perbedaan tampak pada amplitudo puncak P2p yang lebih besar pada HMA (d = 0,77) namun tidak bertahan setelah koreksi perbandingan ganda, serta amplifikasi yang mendekati signifikan pada kondisi rasio sulit (d = 0,69). Efek utama Blok signifikan pada level behavioral dan neural, menandakan sensitivitas paradigma. Pola disosiasi behavioral-neural ini memberikan indikasi performa setara yang disertai beban neural lebih besar pada HMA, searah dengan Attentional Control Theory. Temuan ini menyajikan bukti neurofisiologis awal di Indonesia mengenai keterkaitan MA dengan ANS dan membuka peluang pengembangan intervensi berbasis neurokognitif, dengan catatan keterbatasan daya statistik dan desain yang menuntut replikasi.

Kata kunci: kecemasan matematika; approximate number system; P2p; electroencephalography; Attentional Control Theory