



Measurement characteristics and convergent validity of temporally modulated Gap–Overlap Task versions: Evidence from an Eye-Tracking study in adolescents

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Introduction. Although the gap–overlap paradigm is widely used in eye-tracking research to investigate visual attention disengagement, methodological heterogeneity limits comparability across studies. *Aim.* This study aimed to examine the measurement characteristics and convergent validity of the two most commonly used versions of the gap–overlap task, and to evaluate the sensitivity and robustness of selected eye-movement and fixation-based indicators across experimental conditions. *Methods.* A quantitative, non-experimental design was employed in a normative sample of typically developing adolescents ($N = 53$; $M = 13.98$; $SD = 0.93$). Disengagement of visual attention was assessed using both longer and shorter versions of the gap–overlap task, with eye movements recorded by a Tobii Pro Nano eye tracker. Analysed indicators included performance level, temporal and fixation-based measures, and spatial gaze dispersion indices defined by distance percentiles under baseline (no-gap), gap, and overlap conditions. *Results.* The results showed moderate to very strong convergence between the longer and shorter task versions for most indicators. A robust gap effect was observed in both versions, with the shortest mean saccadic reaction times in the gap condition. Fixation-based and spatial gaze dispersion indices showed consistently high convergence across all experimental conditions, whereas temporal indicators showed greater variability, with weak convergence for mean saccadic reaction time in the overlap

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condition. *Conclusion.* Shortened gap–overlap tasks can provide valid estimates of visual attention disengagement when robust measurement indicators are used. Fixation-based and spatial dispersion metrics show strong convergent validity across task versions, supporting their use in developmental and applied research.

Keywords: gap–overlap paradigm, measurement characteristics, eye tracking, visual attention disengagement, adolescence

Introduction

The human attention system is commonly conceptualised as comprising three functional networks: alerting, orienting, and executive control, according to Posner and Petersen’s model (Petersen & Posner, 2012; Posner & Petersen, 1990). These networks enable the readiness of attention systems for incoming stimuli, the filtering and selection of relevant information, and the regulation of effective perceptual and cognitive processes, allowing effective and flexible responses to stimuli (Fan et al., 2005; Petersen & Posner, 2012; Spagna et al., 2015). The orienting network comprises three sequential processes: directing attention to a specific stimulus, disengaging or withdrawing attention from the current focus or stimulus, and redirecting attention to a new stimulus and spatial location (Posner, 1980; Posner et al., 1984; Posner & Petersen, 1990). These processes also regulate the flexibility and efficiency of visual attention orientation (Chernenok et al., 2019).

In recent decades, the eye-tracking method has been used to study visual attention disengagement in combination with tasks based on the gap-overlap paradigm (Saslow, 1967). This approach has been applied to both normative populations and individuals with developmental disorders (Caldani et al., 2020; Chernenok et al., 2019; de Zwart et al., 2025; Elsabbagh et al., 2013; Rose et al., 2019; Van der Stigchel et al., 2017). Tracking eye movements through video analysis is a risk-free technique that provides objective, accurate, and non-invasive information about which elements of the environment attract an individual’s visual attention (Apicella et al., 2020; Duchowski, 2017). These studies measure eye movement and fixation-based indicators using an eye-tracking device when visual attention shifts from a central to a peripheral visual stimulus under three conditions: a) the gap condition, b) the baseline (no-gap) condition, and c) the overlap condition (Saslow, 1967). The difference in mean saccadic reaction time (RT) between these three conditions is known as the gap effect, which indicates the effectiveness of visual attention disengagement between different visual stimuli in the visual field (Saslow, 1967). Recent studies (Van der Stigchel et al., 2017) have reported a gradual decrease in the size of the gap effect across adolescence, indicating developmentally related improvements in the efficiency of visual attention disengagement.

Although the gap–overlap paradigm is widely used in eye-tracking research on visual attention disengagement, its implementation varies considerably across studies. Existing protocols differ in the temporal configuration of task conditions (baseline (no-gap), gap, overlap), the number of trials administered, and the overall duration of testing (Cousijn et al., 2017; Elsabbagh et al., 2013; Polden et al., 2020). In the gap condition, the central visual stimulus disappeared before the peripheral stimulus onset, facilitating the disengagement of visual attention. In the baseline (no-gap) condition, the offset of the central stimulus and the onset of the peripheral stimulus occurred simultaneously. In the overlap condition, the central stimulus persisted after the appearance of the peripheral stimulus, increasing competition for visual attention and placing greater demands on visual attention disengagement.

Some studies use highly compact designs, while others employ substantially longer protocols with extended inter-trial intervals, longer condition durations, and larger trial counts, particularly in applied or clinical contexts (Chernenok et al., 2019; Polden et al., 2020; Van der Stigchel et al., 2017). In addition, a range of eye movement and fixation-based indicators is used to analyse visual attention disengagement, including mean saccadic reaction time (RT), derived gap-effect measures (e. g. overlap–gap or baseline–gap differences), and the proportion of disengagement failures, particularly in infant and developmental studies (Cousijn et al., 2017; Elsabbagh et al., 2013; Van der Stigchel et al., 2017).

This diversity of task designs and applied protocols limits direct comparability between studies and leaves open the practical question of whether shorter and longer versions of the gap-overlap task capture the efficiency of visual attention disengagement to a comparable degree (de Zwart et al., 2025; Van der Stigchel et al., 2017). This issue is particularly salient in developmental and clinical studies, where testing time, participant fatigue, and data quality must be carefully balanced (Duchowski, 2017; Elsabbagh et al., 2013; Holmqvist et al., 2011).

Despite the frequent use of the gap-overlap paradigm (Saslow, 1967), explicit evaluations of its measurement properties remain rare and are largely limited to specific age groups, most notably infants (Cousijn et al., 2017; Hessels & Hooge, 2019).

Objective

The main objective of the study was to examine the measurement characteristics of the two most commonly used versions of the gap–overlap task and their convergent validity. The secondary objectives were to compare a selected set of eye movement and fixation-based indicators (success rate, mean saccadic RT, fixation duration, and indices of spatial stability of fixations relative to the target, expressed as gaze dispersion percentiles P10, P50, and

P95, or, in short, spatial gaze dispersion P10, P50, and P95) under baseline (no-gap), gap, and overlap conditions. These indicators, obtained using eye-tracking methods, were analysed to test their robustness and sensitivity when comparing longer and shorter versions of the gap-overlap task in a normative sample of typically developing adolescents.

Methods

Sample

A non-probability purposive sampling strategy was used. The initial sample consisted of 60 typically developing adolescents ($N = 60$), aged 12 to 16 years, with normal vision and no identified developmental disabilities, disorders, or impairments. Participants were recruited from a local mainstream primary school in May and June 2024. Demographic and background information, including age, gender, developmental characteristics, and visual status, was obtained from participants' records. Participants were excluded if they had a history of clinically relevant oculomotor abnormalities (e. g. clinically significant nystagmus), epilepsy, or other medical conditions that could interfere with task performance.

Table 1

Demographic Characteristics of the Sample ($N = 53$)

Variable	Value
Age (years), M (SD)	13.98 (0.93)
Age range (years)	12.5–15.6
Gender, n (%)	
Male	21 (39.6)
Female	32 (60.4)
Grade level, n (%)	
Grade 7	16 (30.2)
Grade 8	22 (41.5)
Grade 9	15 (28.3)

Note. M = mean; SD = standard deviation; n (%) = number and percentage of participants.

After applying the exclusion criteria and removing incomplete or invalid eye-tracking data, the final sample consisted of 53 participants ($N = 53$; grades 7, 8, and 9; $M = 13.98$, $SD = 0.93$), representing a relatively narrow age range (Table 1). The sample size is comparable to those used in other eye-tracking studies (Caldani et al., 2020; Chernenok et al., 2019; Elsabbagh et al., 2013; Rose et al., 2019; Van der Stigchel et al., 2017) employing the gap-overlap paradigm. The participants' age group was selected to control for the influence of developmental maturity on disengagement of visual

attention performance, as the literature indicates that visual attention disengagement emerges early in development (Hood & Atkinson, 1993; Johnson, 1990), but its stability and effectiveness continue to develop throughout late childhood, reaching adult levels between ages 10 and 11, when the dorsal stream of visual processing is largely functionally mature (Atkinson, 2017).

Materials and procedure

This study forms part of a doctoral research project conducted at the Faculty of Education, University of Ljubljana. Data from this study will provide reference normative values for future research involving age-matched children with cerebral palsy.

A quantitative, non-experimental design was employed. A child-friendly gap–overlap task, developed by the authors using the Unity game engine (version 2021.3.45f2), was based on relevant empirical literature (Caldani et al., 2020; Chernenok et al., 2019; Elsabbagh et al., 2013; Rose et al., 2019; Van der Stigchel et al., 2017) and implemented in two versions: longer and shorter.

The experimental procedure involved presenting each participant with both versions of the gap–overlap task. Each experimental condition (baseline (no-gap), gap, overlap) lasted 3,500 ms in the longer version of the task and 1,500 ms in the shorter version. The pause between and after each condition trial was 1,000 ms. In both versions, a silent white-blue clock ($2.6^\circ \times 2.6^\circ$ ¹; central visual stimulus) appeared at the centre of the screen at the beginning of the task, expanding and contracting (maximum size $3.5^\circ \times 3.5^\circ$) to attract the participant's attention. After 1,000 ms, in a random order of experimental conditions (baseline (no-gap), gap, overlap), a silent peripheral visual stimulus (animal or object) was presented at 20° to the right or left of the centre of the screen. Both central and peripheral visual stimuli were presented on a black background. In the gap condition, the central visual stimulus disappeared before the peripheral visual stimulus appeared. In the baseline condition, the central visual stimulus disappeared, and the peripheral visual stimulus appeared simultaneously. In the overlap condition, the central visual stimulus remained after the peripheral visual stimulus appeared.

Both the longer and shorter tasks comprised 12 trials for each experimental condition (baseline (no-gap), gap, overlap), resulting in a total of 36 trials per participant. Tasks were administered in a fixed order (the longer task first, followed by the shorter task) within the same test session, with an approximately 30-minute break between them. During the break, participants rested in another room without access to electronic devices or smartphones. Within each task version, the order of experimental conditions (baseline (no-gap), gap, overlap) was randomised across participants to control for order effects at the condition level. A brief recalibration of the eye tracker was conducted before the start of the second task version. This design enabled direct comparison of the two task versions while maintaining internal validity at the experimental condition level.

1 [°] denotes degrees of visual angle.

Participants were seated approximately 60 cm from a 15.6-inch computer screen displaying the task, with a mounted Tobii Pro Nano eye-tracker (60 Hz; Tobii Pro., n. d.-a). Eye-movement and fixation-based indicators (performance level, mean saccadic RT, average gaze duration, average best fixation duration, and spatial gaze dispersion P10, P50, P95) were recorded by the eye-tracking device and processed with the Tobii Pro SDK (Tobii Pro, n.d.-b). Spatial gaze dispersion was calculated as the angular distance in degrees of visual angle ($^{\circ}$) between the gaze position and the centre of the peripheral target, summarised using percentile-based indices (P10, P50, P95). The precision of eye coordinates was approximately 0.5° . The total data collection time per participant and per task was approximately 30-40 minutes, including eye-tracker calibration and a brief practice session to familiarise participants with the procedure.

Data analysis

Raw data were analysed using IBM SPSS Statistics (v. 27). Descriptive statistics were used to examine the sample's demographic characteristics. Descriptive statistics were computed separately for the longer (Table 2) and shorter (Table 3) versions of the eye-tracking task across all experimental conditions (baseline (no-gap), gap, overlap). For each task version, task success rate and temporal indicators of visual attention disengagement (mean saccadic RT, average gaze duration, average best fixation duration) were assessed. Spatial gaze dispersion indices (P10, P50, and P95) were derived from fixation data as measures of spatial attentional stability. In both tests (the longer and shorter versions), average values of eye movement and fixation-based measures were calculated for both eyes and summarised descriptively. P10, P50, and P95 values represent the percentiles of gaze dispersion distance, expressed in degrees of visual angle. The task success rate in each trial is expressed as the percentage of valid trials.

Convergent validity between the longer and shorter versions of the gap-overlap task was assessed using Pearson's product-moment correlation coefficients, calculated separately for each indicator and each experimental condition. Correlation strength was interpreted according to conventional criteria (small: $r \approx .10$; moderate: $r \approx .30$; strong: $r \geq .50$).

Results

Descriptive statistics and task performance

Descriptive statistics for eye movement and fixation-based indicators for both the longer and shorter versions of the gap-overlap task are presented in Tables 2 and 3, respectively. The results show that performance on all tasks in both versions was high, as the average success rates in all three experimental conditions (baseline (no-gap), gap, and overlap) were above 80%.

Table 2

Descriptive Statistics for Eye-tracking Measures in the Long Version of the Gap–Overlap task

Measure	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Baseline condition				
Success rate (%)	95.12	16.30	25.00	100.00
Mean saccadic reaction time (s)	0.998	0.229	0.613	1.636
Average gaze duration (s)	4.055	1.081	0.296	5.173
Average best fixation duration (s)	1.617	0.865	0.008	3.336
Spatial gaze dispersion P10 (°)	0.045	0.170	0.001	0.983
Spatial gaze dispersion P50 (°)	0.419	0.276	0.203	1.485
Spatial gaze dispersion P95 (°)	1.542	2.030	0.473	9.687
Gap condition				
Success rate (%)	86.95	16.39	25.00	100.00
Mean saccadic reaction time (s)	0.295	0.091	0.225	0.868
Average gaze duration (s)	2.452	0.528	0.288	2.787
Average best fixation duration (s)	1.174	0.586	0.008	2.273
Spatial gaze dispersion P10 (°)	0.055	0.180	0.003	1.020
Spatial gaze dispersion P50 (°)	0.453	0.283	0.233	1.531
Spatial gaze dispersion P95 (°)	1.429	1.634	0.510	9.687
Overlap condition				
Success rate (%)	88.37	19.71	8.30	100.00
Mean saccadic reaction time (s)	0.387	0.069	0.247	0.560
Average gaze duration (s)	2.188	0.553	0.224	2.680
Average best fixation duration (s)	1.078	0.550	0.000	2.143
Spatial gaze dispersion P10 (°)	0.052	0.157	0.003	0.824
Spatial gaze dispersion P50 (°)	0.438	0.272	0.194	1.477
Spatial gaze dispersion P95 (°)	1.212	1.147	0.525	4.923

Note. *M* = mean; *SD* = standard deviation; *Min* = minimum score; *Max* = maximum score; time-based measures are expressed in seconds (s); spatial gaze dispersion values are expressed in degrees of visual angle (°).

Table 3

Descriptive statistics for eye-tracking measures in the short version of the gap-overlap task

Measure	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Baseline Condition				
Success rate (%)	97.86	10.58	25.00	100.00
Mean saccadic reaction time (s)	0.656	0.159	0.477	1.376
Average gaze duration (s)	2.293	0.574	0.467	5.173
Average best fixation duration (s)	1.174	0.549	0.000	2.187
Spatial gaze dispersion P10 (°)	0.051	0.164	0.001	1.011
Spatial gaze dispersion P50 (°)	0.421	0.303	0.170	1.597
Spatial gaze dispersion P95 (°)	1.304	1.470	0.440	7.853
Gap Condition				
Success rate (%)	86.95	17.64	25.00	100.00
Mean saccadic reaction time (s)	0.292	0.059	0.215	0.533
Average gaze duration (s)	1.224	0.338	0.413	2.747
Average best fixation duration (s)	0.680	0.305	0.004	1.293
Spatial gaze dispersion P10 (°)	0.049	0.139	0.001	0.777
Spatial gaze dispersion P50 (°)	0.459	0.283	0.222	1.511
Spatial gaze dispersion P95 (°)	1.455	1.703	0.482	9.078
Overlap Condition				
Success rate (%)	82.71	18.99	8.30	100.00
Mean saccadic reaction time (s)	0.301	0.050	0.240	0.492
Average gaze duration (s)	1.215	0.288	0.469	2.680
Average best fixation duration (s)	0.654	0.316	0.004	1.640
Spatial gaze dispersion P10 (°)	0.057	0.160	0.002	0.875
Spatial gaze dispersion P50 (°)	0.442	0.269	0.194	1.499
Spatial gaze dispersion P95 (°)	1.394	1.541	0.473	9.082

Note. *M* = mean; *SD* = standard deviation; *Min* = minimum score; *Max* = maximum score; time-based measures are expressed in seconds (s); spatial gaze dispersion values are expressed in degrees of visual angle (°).

In both versions of the task, success rates were highest in the baseline (no-gap) condition (longer version: 95.12%; shorter version: 97.86%). Performance decreased slightly in the gap condition, with identical success rates in both versions (86.95%). The lowest success rate occurred in the overlap condition, due to competition between central and peripheral stimuli for visual attention. However, success rates remained above 80% in both versions. A direct comparison of the two versions of the gap-overlap test shows that the success rate in the overlap condition was slightly lower in the shorter version (82.71%)

than in the longer version (88.37%). Despite this difference, the results indicate that the shorter version of the gap–overlap test maintains a relatively high success rate even in the most demanding condition.

Eye movement and fixation-based indicators

Clear and systematic differences between the experimental conditions (baseline (no-gap), gap, overlap) were observed in temporal indicators of visual attention disengagement, with a similar pattern in both versions of the task. In the longer version of the gap–overlap task (Table 2), mean saccadic RT were longest in the baseline (no-gap) condition ($M = 0.998$ s), significantly shorter in the overlap condition ($M = 0.387$ s), and shortest in the gap condition ($M = 0.295$ s). A similar distribution of mean saccadic RT was observed in the shorter version of the task (Table 3), although absolute reaction times were generally shorter, particularly in the baseline (no-gap) condition ($M = 0.656$ s). Mean saccadic RT in the gap ($M = 0.292$ s) and overlap ($M = 0.301$ s) conditions were comparable to those in the longer version.

Fixation-based indicators showed a clear and consistent pattern of differences between experimental conditions in both task versions. In the longer version (Table 2), average gaze duration ($M = 4.055$ s) and the duration of the longest fixation ($M = 1.617$ s) were highest in the baseline (no-gap) condition, decreased in the gap condition (average gaze duration: $M = 2.452$ s; longest fixation: $M = 1.174$ s), and were lowest in the overlap condition (average gaze duration: $M = 2.188$ s; longest fixation: $M = 1.078$ s). A similar pattern was observed in the shorter version (Table 3), with consistently lower absolute values: baseline (no-gap) (average gaze duration: $M = 2.293$ s; longest fixation: $M = 1.174$ s), gap ($M = 1.224$ s; $M = 0.680$ s), and overlap ($M = 1.215$ s; $M = 0.654$ s). Despite the lower absolute values in the shorter version, the relative order of the conditions remained unchanged.

Spatial gaze dispersion indices (P10, P50, and P95) also showed similar patterns across experimental conditions and task versions. In the longer version (Table 2), the lower and middle percentiles (P10 and P50) remained stable and comparable across conditions, whereas the upper percentile (P95) showed greater variability. In the baseline (no-gap) condition, the average value of P95 was $M = 1.542^\circ$, decreasing slightly in the gap condition ($M = 1.429^\circ$) and reaching the lowest value in the overlap condition ($M = 1.212^\circ$).

A similar pattern was observed in the shorter version of the task (Table 3), where P10 and P50 remained stable across conditions, while P95 again showed greater variability (baseline (no-gap) $M = 1.304^\circ$; gap $M = 1.455^\circ$; overlap $M = 1.394^\circ$). These results indicate that the spatial gaze dispersion indices in both versions of the task remain stable in the central percentiles (P10 and P50), while the upper percentile (P95) consistently reflects greater variability in gaze dispersion, regardless of protocol length.

Convergent validity between task versions

Pearson's correlation coefficients between the same eye-movement and fixation-based indicators obtained from the longer and shorter versions of the gap-overlap test are presented in Table 4. Overall, the pattern of correlations indicates moderate to very strong convergence between the two task versions across most indicators and experimental conditions.

Table 4

Pearson Correlations Between the Long and Short Versions of the Gap-Overlap Task

Measure	<i>r</i>	<i>p</i>
Baseline Condition		
Success rate (%)	.69	< .001
Mean saccadic reaction time (s)	.33	.017
Average gaze duration (s)	.54	< .001
Average best fixation duration (s)	.77	< .001
Spatial gaze dispersion P10 (°)	.97	< .001
Spatial gaze dispersion P50 (°)	.96	< .001
Spatial gaze dispersion P95 (°)	.71	< .001
Gap Condition		
Success rate (%)	.54	< .001
Mean saccadic reaction time (s)	.64	< .001
Average gaze duration (s)	.44	.001
Average best fixation duration (s)	.79	< .001
Spatial gaze dispersion P10 (°)	.98	< .001
Spatial gaze dispersion P50 (°)	.93	< .001
Spatial gaze dispersion P95 (°)	.54	< .001
Overlap Condition		
Success rate (%)	.56	< .001
Mean saccadic reaction time (s)	.10	.476
Average gaze duration (s)	.38	.005
Average best fixation duration (s)	.74	< .001
Spatial gaze dispersion P10 (°)	.99	< .001
Spatial gaze dispersion P50 (°)	.97	< .001
Spatial gaze dispersion P95 (°)	.79	< .001

Note. Exact *p* values are given when $p \geq .001$. Otherwise, $p < .001$ is shown.

In the baseline condition, correlations ranged from moderate for mean saccadic RT ($r = .33, p = .017$) to very strong for fixation-based and spatial gaze dispersion indices, particularly for the lower and middle indices (P10: $r = .97$; P50: $r = .96$; both $p < .001$). The duration of the longest fixation also showed a strong correlation between the longer and shorter versions of the test ($r = .77, p < .001$). A similar pattern was observed in the gap condition. Temporal indicators showed moderate to strong correlations (mean saccadic RT: $r = .64$; average gaze duration: $r = .44$), while fixation duration ($r = .79$) and lower and middle spatial gaze dispersion indices (P10–P50: $r \approx .93$ – $.98$) showed very high convergence between the two task versions (all $p \leq .001$). In the overlap condition, most indicators again showed moderate to strong convergence. Performance rate ($r = .56$), average gaze duration ($r = .38$), and longest fixation duration ($r = .74$) were statistically significantly correlated between the two task variants. All spatial gaze dispersion indices showed extremely strong correlations (P10: $r = .99$; P50: $r = .97$; P95: $r = .79$; all $p < .001$). In contrast, the mean saccadic RT in the overlap condition showed a weak and statistically insignificant correlation ($r = .10, p = .476$), which is consistent with the limited inter-individual variability of this indicator in the shorter version of the task.

Overall, the correlational findings show a high degree of convergence between the longer and shorter versions of the gap–overlap test, particularly for fixation-based and spatial gaze dispersion indicators of visual attention disengagement. Temporal indicators showed greater variability in the degree of correlation between experimental conditions, with the weakest convergence observed for mean saccadic RT in the overlap condition ($r = .10, p = .476$).

Discussion

This study examined the measurement characteristics and convergent validity of two versions of the gap–overlap task for assessing visual attention disengagement. The longer and shorter versions of the gap–overlap task were compared through direct analysis of eye movement and fixation-based indicators across three experimental conditions (baseline (no-gap), gap, overlap) in a normative sample of adolescents, during a developmental period when dorsal stream visual processing functions are largely mature (Atkinson, 2017). By systematically comparing both versions of the gap–overlap task in the baseline (no-gap), gap, and overlap conditions, the study provides empirical evidence on the comparability of visual attention disengagement in shortened protocols.

The correlation results provide strong evidence for the convergent validity of the shorter version of the gap–overlap task. In all experimental conditions (baseline (no-gap), gap, overlap), most eye movement and fixation-based indicators showed moderate to very strong correlations between the longer and shorter versions of the gap–overlap task, indicating substantial

overlap in the constructs measured by both. The strongest convergence was consistently observed in fixation-based and spatial gaze dispersion indicators, while temporal indicators showed greater variability in correlation strength, including weak convergence for mean saccadic RT in the overlap condition.

This trend aligns with psychometric studies indicating that individual outcomes and the developmental timeframe of the gap–overlap task vary in reliability, and that the task’s temporal parameters are important for measurement stability and result comparability (Cousijn et al., 2017; de Zwart et al., 2025; Van der Stigchel et al., 2017). For applied use, the results imply that shorter procedures effectively minimise testing times and participant strain, and increase completion rates, provided the outcome instruments remain stable and methodologically appropriate (Duchowski, 2017; Elsabbagh et al., 2013; Holmqvist et al., 2011), especially in younger children and clinical populations. Thus, the results directly address the study’s primary objective of evaluating measurement characteristics and convergent validity across task versions.

The presence of a pronounced gap effect in both versions of the gap–overlap task, indicated by the shortest mean saccadic RT in the gap condition, aligns with extensive literature consistently showing that prior removal of the central stimulus facilitates disengagement of visual attention and oculomotor preparation (Csibra et al., 1997; Fischer & Weber, 1993; Reuter-Lorenz et al., 1995; Saslow, 1967; Van der Stigchel et al., 2017). Fixation-based indicators (average gaze duration and average duration of the best fixation) were also systematically modulated across experimental conditions, confirming that both versions of the gap–overlap task capture meaningful changes in attention allocation as perceptual and cognitive demands increase.

Crucially, the shorter version of the gap–overlap task retained the relative pattern of differences between experimental conditions, although the absolute values of the mean temporal indicators were generally lower. This suggests that the time compression and condensed design of the shorter gap–overlap task primarily affect the overall response rate rather than the qualitative pattern of visual attention disengagement. This finding has important practical implications for developmental and applied research, where test duration, participant fatigue, cooperation, and data quality are key methodological constraints (Duchowski, 2017; Elsabbagh et al., 2013; Holmqvist et al., 2011).

Both versions of the gap–overlap task showed systematic modulation of temporal and spatial gaze dispersion indicators, consistent with the theoretical expectations of the gap–overlap paradigm, in which fixation disappearance facilitates disengagement (gap condition), while conditions without prior disappearance (baseline (no-gap) and overlap conditions) impose additional constraints on orienting control (Hood & Atkinson, 1993; Posner, 1980; Saslow, 1967). This is in line with broader interpretations of goal- and stimulus-driven attention control and their neural bases (Corbetta & Shulman, 2002; Petersen

& Posner, 2012), as well as developmental studies showing that attention networks and their interactions continue to consolidate throughout childhood and adolescence (Federico et al., 2017; Luna et al., 2010, 2015; Klein et al., 2024; Pozuelos et al., 2014). A central methodological contribution of this study concerns the robustness of fixation-based and spatial gaze dispersion indicators. Across all conditions, the duration of the longest fixation and the lower and middle spatial gaze dispersion indices (P10 and P50) showed very high convergence between the longer and shorter task versions. This suggests that fixation-based and percentile-based spatial measures capture relatively stable aspects of visual attention disengagement that are less sensitive to variations in task duration and temporal structure.

From a measurement perspective, this aligns with recommendations in eye-tracking research, as fixation-based indicators integrate information across multiple consecutive patterns, whereas mean saccadic RT are single, temporally specific events that are more susceptible to sampling frequency limitations, noise, artefacts, distribution asymmetry, head movement, transient drops in visual attention, and algorithmic fixation detection (Carter & Luke, 2020; Duchowski, 2017; Hessels & Hooge, 2019; Hessels et al., 2017; Holmqvist et al., 2011), especially in studies involving younger populations and individuals with developmental disorders. Developmental research further supports the view that patterns of fixations and spatial scanning of the environment are often more stable across different experimental designs than precise temporal indicators of latency (Colombo, 2001; Helo et al., 2014).

Within this framework, spatial gaze dispersion indices provide a valuable methodological complement to temporal measures of visual attention disengagement. The lower and middle spatial gaze dispersion indices (P10 and P50), which showed high convergent validity in the present study and further supported methodological recommendations (Carter & Luke, 2020; Hessels & Hooge, 2019; Holmqvist et al., 2011), contribute to greater reliability in assessing the spatial stability of attention, as they are less sensitive to extreme values and variability at the tail of the distribution. Conversely, the upper spatial gaze dispersion index (P95) provides insight into variability and attentional instability under increased perceptual and cognitive demands. The present findings demonstrate the added value of percentile-based spatial metrics and directly address the study's second objective by identifying fixation-based and spatial indicators as the most robust and convergent measures across task versions. This multi-indicator approach is particularly promising for developmental, rehabilitation, and clinical research, where qualitative aspects of attentional stability and heterogeneity are central (Apicella et al., 2020; Hessels & Hooge, 2019; Sekigawa-Hosozawa et al., 2017).

An atypical but theoretically informative finding was that mean saccadic RT were longest in the baseline (no-gap) condition, diverging from

the more commonly reported pattern in which the overlap condition produces the longest latencies (Cousijn et al., 2017; de Zwart et al., 2025; Hood & Atkinson, 1993; Saslow, 1967; Van der Geest et al., 2001; Van der Stigchel et al., 2017). The longer baseline mean saccadic RT are most plausibly explained by implementation and methodological factors, particularly the longer response window in the longer version (3, 500 ms in the longer vs 1, 500 ms in the shorter version), which increases the likelihood that very late saccades are still recorded as valid latencies rather than being “cut off” or treated as failed attempts, and the use of mean saccadic RT, which are sensitive to the right tail of the distribution, rather than distribution-robust latency metrics (Van der Stigchel et al., 2017).

In this context, the results highlight the need for transparent reporting and cautious interpretation of the effects of the baseline (no-gap) condition. It is crucial that the findings align with the core of the paradigm, namely the gap effect, as in both versions of the task, the gap condition was associated with the shortest latencies (Reuter-Lorenz et al., 1995; Saslow, 1967; Van der Stigchel et al., 2017). The deviation therefore mainly concerns the contrast between the baseline (no-gap) and overlap conditions. These findings indicate that the baseline (no-gap) condition is not a methodologically neutral reference, but depends on the specific task implementation, and should not be assumed to be a universal comparative baseline across studies. This emphasises the importance of transparent reporting and cautious interpretation of baseline effects.

Conclusion

This study confirms that even shortened gap–overlap task protocols can provide reliable and sensitive estimates of visual attention disengagement when eye movement and fixation-based indicators are selected based on their measurement properties. Although temporal indicators vary with protocol duration, fixation-based and spatial gaze dispersion indices (P10, P50, and P95) show strong convergent validity regardless of the task’s temporal implementation. The findings support the use of the shortened gap–overlap task format in developmental studies and provide a methodologically rigorous foundation for more efficient and standardised assessment of visual attention disengagement.

Limitations of the Study

The sample size was relatively small, which may limit the generalisability of the results beyond the age group studied. Eye movements were recorded using a 60 Hz eye tracker, which may reduce sensitivity to very small differences in saccade latencies. However, the same technical settings and recording parameters were used consistently in both versions of the task, ensuring that this

limitation does not compromise the validity of comparative analyses between the longer and shorter protocols. Therefore, the main conclusions regarding measurement equivalence and convergent validity remain robust.

Future Directions

These results should be replicated with larger samples in future studies. In addition, using longitudinal designs to clarify the developmental stability of visual attention disengagement across the lifespan would be valuable. Extending research to children with developmental disorders or specific learning difficulties is an essential step in future rehabilitation research.

Ethics Statement

The study was approved by the Ethics Committee of the Faculty of Education, University of Ljubljana (Decision No. 17/2021) and conducted in full accordance with the principles of the Declaration of Helsinki. All participants and their guardians received an explanation of the study's objectives and procedures, and written informed consent was obtained before participation. Data protection legislation was observed in processing individual data, in accordance with established educational research ethical standards.

Data Availability Statement

The data presented in this paper are available upon request from the corresponding author.

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Conflict of interest

The authors have no conflicts of interest to declare.

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Merne karakteristike i konvergentna validnost vremenski modifikovanih verzija gap-overlap zadatka: Dokazi iz studije praćenja pokreta očiju kod adolescenata

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Uvod: Iako se paradigma gap-overlap široko koristi u istraživanjima praćenja pokreta očiju za ispitivanje isključenja vizuelne pažnje, metodološka heterogenost ograničava uporedivost nalaza između studija. *Cilj:* Cilj studije je da se ispituju merne karakteristike i konvergentna validnost dve najčešće korišćene verzije gap-overlap zadatka, kao i da se proceni osetljivost i robusnost odabranih indikatora pokreta očiju i fiksacija u različitim eksperimentalnim uslovima. *Metode:* Primenjen je kvantitativni, neeksperimentalni istraživački dizajn na normativnom uzorku tipično razvijenih adolescenata ($N = 53$; $M = 13.98$; $SD = 0.93$). Isključenje vizuelne pažnje procenivano je pomoću duže i kraće verzije gap-overlap zadatka, pri čemu su pokreti očiju snimani pomoću uređaja Tobii Pro Nano. Analizirani indikatori obuhvatali su stepen uspešnosti, vremenske i fiksacijske mere, kao

i prostorne indikatore disperzije pogleda, definisane percentilima udaljenosti, u uslovima baseline (no-gap), gap i overlap. *Rezultati:* Rezultati su pokazali umerenu do veoma snažnu konvergenciju između duže i kraće verzije zadatka za većinu indikatora. U obe verzije potvrđen je izražen gap efekat, pri čemu su najkraće prosečne latencije sakadičnih pokreta očiju zabeležene u gap uslovu. Fiksacijski i prostorni indikatori disperzije pogleda pokazali su dosledno visoku konvergenciju u svim eksperimentalnim uslovima, dok su vremenski indikatori pokazali veću varijabilnost, uz slabu konvergenciju prosečne latencije sakadičnih pokreta očiju u overlap uslovu. *Zaključak:* Kraće verzije gap-overlap zadatka mogu obezbediti validne procene isključenja vizuelne pažnje ukoliko se koriste robusni merni indikatori. Fiksacijske mere i prostorni indikatori disperzije pogleda pokazuju snažnu konvergentnu validnost između verzija zadatka, što podržava njihovu primenu u razvojnim i primenjenim istraživanjima.

Cljučne reči: gap-overlap paradigma, merne karakteristike, praćenje pokreta očiju, isključenje vizuelne pažnje, adolescencija

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