The impact of developmental dyslexia on workplace cognition: Evidence from a virtual reality environment

Dyslexia and workplace cognition

James H. Smith-Spark

Division of Psychology, School of Applied Sciences, London South Bank University, United Kingdom, smithspj@lsbu.ac.uk

Rebecca Gordon

Department of Psychology and Human Development, Institute of Education, University College London, United Kingdom, rebecca.gordon@ucl.ac.uk

Ashok S. Jansari

Department of Psychology, Goldsmiths, University of London, United Kingdom, a.jansari@gold.ac.uk

The cognitive difficulties associated with dyslexia persist into adulthood but insights into their impact in employment settings are lacking. A virtual office environment was used to assess two areas of cognition frequently called upon in the workplace, executive function and prospective memory. Eight adults with dyslexia and 27 adults without dyslexia were tested on a virtual office task. They read a scenario describing their new role in an office and were given tasks to complete. The group with dyslexia performed worse overall. On the individual performance measures, the group with dyslexia scored lower on the selective-thinking and planning measures of executive function and also performed worse on two of the three prospective memory measures, namely event-based and time-based prospective memory. The findings indicate how dyslexia can affect workplace cognition, identifying areas in which support might be needed and highlighting areas of relative strength which might be harnessed.

CCS CONCEPTS • Applied computing ~Law, social and behavioral science ~Psychology • Social and professional topics ~User characteristics ~People with disabilities

Additional Keywords and Phrases: Developmental Dyslexia; Executive function, Prospective memory, Virtual reality, Workplace cognition

ACM Reference Format:

First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2022. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium

on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1 INTRODUCTION

The recognition of, and support for, neurodiversity in the workplace has been growing in importance in recent years (e.g., [1, 2, 3]). Neurodiversity refers to all specific learning difficulties, such as attention deficit hyperactivity disorder, autism, developmental coordination disorder, and developmental dyslexia, which often co-occur or whose symptoms overlap. The focus of the current paper is on one such condition, developmental dyslexia (henceforth, dyslexia). Dyslexia is typically characterized as a specific impairment affecting phonological processing and the subsequent development of reading and spelling (see, for example, a review by [4]. However, broader cognitive deficits have also been found, including problems with executive function (e.g., [5, 6, 7]) and memory (e.g., [8, 9, 10]). As a neurodevelopmental condition, the effects of dyslexia persist into adulthood and the demands placed on cognitive resources in adulthood are likely to be very different from those required in childhood (e.g., [11]). One clear and obvious difference is the need for cognition in employment settings. While there is some literature on the impact of dyslexia in the workplace (e.g., [12, 13, 14]), there is considerably less research that takes a specifically cognitive perspective on its effects in employment settings. A greater understanding of the direct impact of dyslexia on workplace functioning is needed in order to ensure that the full range of its effects are understood and that reasonable adjustments to working practices are well targeted. The research reported in the current paper focused on two broader and inter-related areas of cognition, executive function and prospective memory (PM), which dyslexia has been found to affect in adults (e.g., [5, 6, 15]) and which are relevant to the workplace. To this end, the current study used a virtual office environment to investigate how dyslexia-related deficits in two complex aspects of cognition, executive function and PM, might affect workplace performance.

There is a relatively small literature on the effects of dyslexia in the workplace. However, a range of hindering or facilitative factors relevant to the challenges adult with dyslexia face in the workplace have been identified [12]. These include feelings and emotions about their condition, activities involving reading and writing, becoming employed and maintaining employment, attitudes of fellow employees and managers towards dyslexia, the availability of assistive technology in the workplace and other dyslexia-related accommodations, and self-disclosure and coping strategies. The positive effects of coaching on both literacy skills and cognition in the workplace have also been reported [13, 14], with it being found [13] that coaching topics were much more likely to be centered around executive function (relating in particular to working memory, organizational skills, and time management) than literacy-related skills. Indeed, they argue, based on their data, that problems with executive function are a "prominent feature" (p. 162) of dyslexia in occupational settings. A positive relationship between both planning and metacognitive abilities and job satisfaction and self-efficacy has been highlighted [16], although these factors were not found to relate to salary level, promotion or academic qualifications. There is also a small literature highlighting the impact of dyslexia on the nursing profession [17, 18], particularly highlighting the need for support and acceptance from colleagues and managers regarding the condition. Further to this empirical work, there are also books which have considered dyslexia in the workplace (e.g., [19, 20, 21]), highlighting further challenges and providing some approaches to alleviating them. However, the effects of dyslexia on office jobs, and in particular the cognition related to carrying out duties in this kind of employment, are underexplored.

The executive functions are a set of higher-order cognitive abilities that enable goal-oriented behaviors [22]. The cognitive mechanisms involved in goal success are inhibiting inappropriate behaviors (inhibition), switching attentional focus based on internal or external demands (task-switching), and concurrently processing and remembering information to enable rule maintenance and task focus (working memory) [23]. Such core mechanisms work in concert to facilitate

downstream executive abilities including planning, prioritisation, decision making and, indirectly, PM [23]. There is some evidence for the impact of executive deficits in the workplace, indicating a need for frameworks and practices which assist those who struggle with executive deficits [24].

Executive function problems are well documented in dyslexia (see [25] for a theoretical review of the links between dyslexia, executive function, and reading). Problems with executive function have been found to persist into adulthood (e.g., [5, 6]). Indeed, in the same sample of adults, dyslexia-related deficits have been found across all three core executive functions of Miyake et al.'s [23] theoretical framework [6]. As well as showing executive function impairments under laboratory conditions, the same participants self-reported a more frequent incidence of executive function problems in everyday life. These everyday problems were loaded on metacognitive processes (namely, organization, planning, task monitoring, and working memory) but not the regulation of emotion and behavior. The findings of this study indicate both the broad range of executive functions affected by dyslexia and also the ubiquity of their impact across everyday settings.

The PM system is responsible for remembering delayed intentions [26]. Prospective memory is made up of two main components (e.g., [27; 28]), a prospective component and a retrospective component. The role of the prospective (or planning) component is to remind the individual, at the right time, that there is an intention which needs to be acted upon. The role of the retrospective component, on the other hand, is to inform the individual of the actual contents of the intention. Three types of PM task cue have been identified in the literature (e.g., [29]), namely event-based, time-based, and activity-based. Of these, event-based and time-based PM are the two most studied. In event-based PM, objects in the individual's surrounding environment act as cues to support PM (e.g., seeing a postbox should remind the individual that there is a letter in his or her bag which needs to be posted). Time-based PM requires an intention to be acted upon at or by a particular timepoint in the future (e.g., paying a bill by the end of the following week or returning a telephone call later the same day). Prospective memory of this kind is self-initiated and relies on internally-generated cues to support remembering, drawing upon executive function (e.g., [30, 31]). Like event-based PM, action-based PM intentions are environmentally cued and requires an intention to be carried out after another task has been performed (e.g., 29, 32]). Action-based PM is considered to be the least cognitively demanding as the external cues associated with it coincide with the completion of the ongoing activity itself [33]. Of the three cue types, time-based PM is considered to be the most cognitively complex and to draw on executive function to a greater extent than either event-based or action-based PM (e.g., [34]).

The uses of PM in the workplace are manifold; for example, in remembering to carry out tasks, attach documents to emails, attend meetings, and pass on messages to colleagues. The real-world challenges of carrying out PM tasks are, for instance, coping with interruptions, dealing with busy and demanding situations, and monitoring for rarely occurring events over extended time periods [35]. Its importance in safety-critical work settings has been highlighted (e.g., [36]), while PM has also been studied in a work environment through the use of active badges logging participants movements and actions during their work day [37]. The role of PM in recovering from interruption of work tasks has also been studied [e.g., 38]. In the context of ergonomics, the role of PM has been investigated, for example, in air-traffic control (e.g., [39]), driving behavior [40], intensive care units [41], and, more generally in complex sociotechnical systems [42]. This literature indicates the involvement in, and importance of, PM across a range of employment settings and work tasks.

In dyslexia, self-reports have indicated higher frequencies of PM problems in everyday life in adults [43, 44]. Under controlled laboratory conditions, adults with dyslexia have also been found to perform worse than adults without dyslexia on a computerized time-based PM task [45] and on a clinical test of PM [44]. Prospective memory tasks with more naturalistic and less artificial task demands have also revealed dyslexia-related PM problems in adults with dyslexia [44, 45, 46]. It has been argued [15] that dyslexia has its greatest impact on PM when cues to remembering are time-based rather than event-based, when the delay between forming an intention and being able to act upon it is prolonged, and when

PM is required for one-off rather than habitual events. In addition to lowered PM accuracy under such conditions, the ability to recall PM instructions over longer delay intervals is also reduced in individuals with dyslexia. Conversely, habitual PM and event-based PM (at least in the short-term; but see [46], for evidence of dyslexia-related problems on a naturalistic measure of event-based PM over a one-week delay period) do not seem to be affected by the condition. There is, therefore, evidence of the continued impact of dyslexia on cognition in adulthood and some of this has highlighted its effects on everyday performance. However, it is clear from the limited literature on the effects of dyslexia on cognition in the workplace that a specific understanding of its effects in employment settings is lacking. The aim of the current study was, therefore, to obtain a more direct assessment of the impact of dyslexia on workplace-related executive function and PM.

To this end, the Jansari assessment of Executive Function (JEF) [47] was used to provide a novel and ecologically valid assessment of executive function in adults. The JEF uses a computer-based, non-immersive virtual reality environment to assess executive abilities across eight constructs; namely planning, prioritization, selection, creative-thinking, adaptive-thinking, action-based PM, event-based PM, and time-based PM. Resembling a computer game, the participants roleplay working in an office on their first day in a new job. The experimenter reads out loud a list of instructions to the participant from a prepared script, making them aware of the rules and procedures required of them. Participants navigate around the VR environment using a standard laptop keypad. They are required to interact with objects by clicking them with the computer mouse. The participant is scored on their performance for each task undertaken. Specifically, executive function is assessed by performance on tasks designed to measure planning, prioritisation, selection, adaptive-thinking, creative-thinking and multi-tasking. Prospective memory is assessed using tasks design to measure action-based PM (i.e., triggered by an action undertaken by the participant, such as a chair breaking when it is being moved), event-based PM (i.e., triggered by an event external to the participant, such as someone delivering a message to be noted) and time-based PM (i.e., a task to be performed at a specific time point). Tasks were chosen that might be considered typical in an office environment and were designed to appear to have more than one possible solution, but only one optimal solution.

Based on the literature reviewed in this section, it was hypothesized that the performance of the group with dyslexia on the JEF [47] would be lower overall than that of the group without dyslexia. On the individual JEF measures, some predictions were also made based on the previous literature. Similarly, it was predicted that the dyslexia group would score lower on measures of planning. There is a small literature on planning in dyslexia, with deficits having been reported in children [48, 49, 50]. Dyslexia-related planning deficits have also been reported in adults in educational contexts, with these difficulties playing out in problems with planning and structuring essays [51, 52, 53]. However, despite strong implications for the role of executive functions in planning behaviors, this ability is under-explored in adults with dyslexia in the workplace. Due to the evidence for the role of executive functions in prioritization and selective thinking [e.g., 54], it was predicted that the adults with dyslexia would perform worse on these tasks.

Anecdotally, people with dyslexia have been argued to be high in creativity. It remained to be seen whether this would translate to better performance by the group with dyslexia on the creative-thinking measure of executive function. The Model of Control of Action [54] posits that the Supervisory Attentional System (SAS) interrupts automatic behaviors to adapt to environmental demands. Given the evidence for impairment in SAS-related abilities in adults with dyslexia [6, 10], it was predicted that the group with dyslexia would score lower on the adaptive-thinking tasks.

Dyslexia-related deficits were also expected to be found on the PM measures, with differences being more pronounced on the time-based PM measure (in line with [44, 45, 46]). Action-based PM has not previously been explored in dyslexia. However, given that it is considered to be less cognitively taxing than event-based PM [33] and given the evidence

indicating no event-based PM deficits over shorter delay intervals (e.g., [44]), it was expected that there would be a reduced impact of dyslexia on performance.

2 METHOD

2.1 Participants

A total of 35 adults (27 females, eight males, mean age = 24 years, *SD* = 5.63) took part in the study. These participants were allocated to one of two groups based on their self-declared dyslexia status. The group with dyslexia consisted of eight participants (five females, three males, mean age = 25 years, *SD* = 5.84), while the group without dyslexia was made up of 27 participants (24 females, 3 males, mean age = 24 years, *SD* = 5.66). There was no statistically significant difference in age between the participant groups, $t(36) < 1$, $p = .670$. Prior to testing, the participants in the group with dyslexia showed the experimenter an educational psychologists' report to confirm their diagnosis. When asked by the experimenter, none of the participants without dyslexia identified any problems with reading or spelling.

As a further means of checking the allocation of the participants to the different groups, two additional tasks were administered to all the participants. These were the Nonsense Word Reading Passage (NWR) from the Dyslexia Adult Screening Test (DAST; [55])) and the spelling component of the Wechsler Objective Reading Dimensions (WORD; [56]).

The DAST NWR [55] required the reading out loud of a short text containing both real words and orthographically legal nonsense words. The time taken to read the passage and the accuracy of reading performance were combined to provide a composite index of reading ability, following the method set out in the publication manual. On average, the group without dyslexia produced higher total scores on the DAST NWR (mean = 89.72, *SD* = 7.74) than the group with dyslexia (mean = 76.72 *SD* = 13.82). This group difference in reading ability was found to be statistically significant, $t(8.343) = 2.55$, $p = .033$, Cohen's $d = 1.22$). Levene's test for equality of variances was found to be significant, so a reduced number of degrees of freedom is reported.

The WORD spelling component [56] required the spelling of individual words of increasing difficulty. Each word was read out loud by the experimenter, then read in the context of a sentence, then the individual word was repeated. Testing was terminated after six successive incorrect responses, in line with the guidance set out in the publication manual. Performance on the test yielded two measures of reading ability, the overall number of words spelled correctly and the spelling age of the participant (with a ceiling of < 17 years, indicating a spelling age in the typical adult range). The mean score of the group without dyslexia was 46.63 (*SD* = 2.02), while that of the group with dyslexia was 41.13 (*SD* = 4.42). The group difference in spelling scores was found to be highly significant, $t(33) = 5.04$, $p < .001$, Cohen's $d = 1.54$). Five of the eight participants with dyslexia had a spelling age of less than 17 years, while all the participants without dyslexia had spelling ages that fell in the typical adult range.

2.2 Materials

The JEF is a virtual reality assessment wherein the participant assumes the role of an office assistant on their first day in a new job. Performance is assessed via tasks related to eight cognitive constructs: 'planning', 'prioritization', 'selection', 'creative thinking', 'adaptive thinking'. Prospective memory is assessed using three tasks related to 'action-based', 'event-based' and 'time-based' PM. In total, there are 22 tasks (two for each construct). Performance on each task is assessed using a three-level scoring system (0 = task not completed; 1 = partially completed; 2 = task completed) based on predetermined criteria. For example, one of the planning tasks requires the participant to list the tasks in an order which is logical and efficient. The scoring protocol has been validated using inter-rater reliability in previous studies [57].

2.3 Design

A between-subjects design was employed. A multivariate analysis of variance (MANOVA) tested for group differences in JEF performance. The between-subjects factor was participant group (levels: group with dyslexia, group without dyslexia). The dependent variables were the eight JEF measures (planning, prioritization, selection, creative-thinking, adaptive-thinking, action-based PM, event-based PM, and time-based PM).

2.4 Procedure

Full ethical approval was granted by the relevant research ethics committee at the first author's host institution.

Testing was divided between two sessions, which occurred on different days. In the first, the reading and spelling measures were administered. In the second, the participants were presented with the virtual office task. For the JEF assessment, participants were asked to read a scenario describing their new role in an office, and were then shown how to navigate around the office virtual environment. Once they had been given time to practice using the program, they were given a list of tasks to complete. They were also told that their manager was not in the office that day. The participant was provided with a number of "To Do" items throughout the assessment which created additional tasks or events, similar to those that would usually occur in an office environment. The participants were debriefed after the second testing session.

3 RESULTS

The descriptive statistics for each of the individual JEF measures are shown in Table 1. Inspection of the means indicates that the participants with dyslexia scored lower on all measures except creative-thinking, where they scored higher.

Table 1: Descriptive statistics for each of the individual JEF measures

Measure name	Mean (*SD*) of the group with dyslexia	Mean (*SD*) of the group without dyslexia
Planning	39.58 (8.63)	77.15 (18.57)
Prioritisation	81.25 (17.68)	86.11 (16.01)
Selective-thinking	81.25 (22.16)	96.30 (9.05)
Creative-thinking	43.75 (39.53)	33.33 (36.69)
Adaptive-thinking	81.25 (17.68)	83.33 (21.93)
Action-based PM	68.75 (29.12)	77.78 (25.32)
Event-based PM	68.75 (29.12)	91.67 (15.50)
Time-based PM	71.88 (20.86)	90.74 (12.30)

There was a highly significant multivariate effect of participant group on JEF performance, Wilks' $\Lambda = .379$, $F(8, 26) = 5.34$, $p = .001$, $\eta_p^2 = .621$. The univariate *F*-test results are shown in Table 2. They indicated that the group with dyslexia performed significantly worse than the group without dyslexia on two of the five executive function measures (planning and selective-thinking) and two of the PM measures (event-based PM and time-based PM). The group differences on the remaining JEF measures were not found to be statistically significant.

Table 2: Univariate *F*-test results for the individual JEF measures

Measure name	$F(1, 33)$	p	η_p^2
Planning	30.28	< .001	.479
Prioritisation	< 1	.466	.016
Selective-thinking	8.28	.007	.201

Measure name	$F(1, 33)$	p	η_p^2
Creative-thinking	< 1	.493	.014
Adaptive-thinking	< 1	.808	.002
Action-based PM	< 1	.398	.022
Event-based PM	8.78	.006	.210
Time-based PM	10.38	.003	.239

To explore the relationship between dyslexia symptomatology and JEF performance further, Pearson's correlations were performed on the reading and spelling scores of all the participants and scores on the JEF. The correlation matrix is shown in Table 3. Spelling ability, as measured by the WORD spelling component, was significantly correlated with scores on the JEF planning, event-based PM, and time-based PM measures. Reading ability, assessed by the DAST NWR, was found to have significant associations with scores on the JEF prioritisation, event-based PM, and time-based PM measures.

Table 3: Correlations between the reading and spelling measures and the JEF measures

Measure	WORD	NWR	Planning	Prioritisation	Selection	Creativity	Adaptiveness	ABPM	EBPM	TBPM
WORD spelling	-									
DAST NWR	.811***	-								
Planning	.533**	.403	-							
Prioritisation	.163	.516*	.013	-						
Selection	.285	-.205	.227	.158	-					
Creativity	.623	.049	-.253	.214	.079	-				
Adaptiveness	.428	.289	-.058	.358*	.256	.031	-			
Action-based PM	.037	.310	.221	.156	-.134	-.256	.193	-		
Event-based PM	.593***	.528*	.302	.138	.457**	-.160	.331	.183	-	
Time-based PM	.504**	.517*	.263	.454**	.592***	.125	.482**	.023	.561***	-

Key: ABPM = action-based PM; EBPM = event-based PM; TBPM = time-based PM; * = $p < .05$, ** = $p < .01$, *** = $p < .001$

4 DISCUSSION

In this study, the workplace cognition of adults with dyslexia was compared with that of adults with dyslexia using the virtual reality JEF [47]. Overall, the participants with dyslexia performed at a lower level than the participants with dyslexia, indicating deficits in the application of executive function and PM to work-related tasks. Group differences were found on two of the executive function measures, namely planning and selective-thinking, with the group with dyslexia performing worse than the group without dyslexia on both the measures. As noted previously, the planning measure assesses the ability of the participant to order events or objects on the basis of logic (and not relative importance). This is in line with research findings related to dyslexia-related planning problems in childhood [48, 49, 50] and adulthood [51]. Selective-thinking refers to the ability to draw on acquired knowledge to choose between two or more alternatives. Controlled access to information from long-term memory has been shown to be impaired in people with dyslexia. For example, adults with dyslexia have been found to perform worse on a verbal fluency task than adults without dyslexia [58]. Given that selective thinking requires rapid access to existing information, it could be argued that this finding adds to the small amount of extant research in this area and shows a way in which such difficulties might affect everyday cognition. Employees with dyslexia need to be aware of potential difficulties with planning and selective thinking and discuss with employers appropriate methods of support in these areas (e.g., alternative strategies or software applications).

The group with dyslexia also performed worse on two of the three PM measures, with deficits being shown on both the event-based and time-based PM measures. In line with previous findings [44], the effect size was larger (albeit slightly)

for time-based PM than for event-based PM. As argued previously, time-based PM is considered to be more executive-loaded (e.g., [30, 31]) and, given the executive function problems in dyslexia, likely to be more prone to the effects of the condition (see [15]). No group difference was found on the action-based PM measure. As stated in the Introduction, this form of PM is considered to be both the least complex [33] and the most environmentally-supported [29, 32, 33]. These task qualities are likely to explain the absence of a group difference on this measure. Areas of relative strength in PM can be utilized to improve performance to a level at least equivalent of that of individuals without dyslexia [15]. From the current data, it would seem that workers with dyslexia should aim, wherever possible, to change the nature of the work-based PM tasks that they are assigned so that they rely on action-based cues.

As further support for the relationship between dyslexia symptomatology and aspects of work-based cognition, significant positive correlations were found between scores on the reading and spelling measures and several JEF measures. In the case of the executive function measures, planning was correlated with spelling ability and prioritization with reading ability. A more consistent pattern was found with the PM measures, with both reading and spelling ability being associated with event-based and time-based tasks, but not action-based tasks. The results from the current study, therefore, add to the evidence that adults with dyslexia might struggle performing work-related planning tasks.

There are several limitations to the current study. The participants were university students rather than office workers. Further work is thus needed to examine any mitigating role that office experiences might play in the performance of workers with dyslexia. The number of participants in the group with dyslexia was small but, where significant group differences were found, the effect sizes were relatively large. It should also be noted that no measure of IQ was administered but the findings are consistent with previous work where measures of IQ were taken [44, 45] and in which no group differences in IQ were found.

This virtual reality study has allowed the direct study of workplace cognition in adults with dyslexia, indicating areas of weakness and relative strength in executive function and PM abilities that are relevant to office settings. The knowledge gained from this study can help in providing targeted support for employees with dyslexia in areas of workplace cognition beyond those drawing on literacy-related skills. The results also highlight the value of virtual reality methodologies in testing office-based cognition, allowing insights into the ways in which neurodiversity can be expressed in the workplace and emphasizing the need for appropriate support to be in place to help all individuals achieve their full potential and to gain maximum satisfaction in their work.

ACKNOWLEDGMENTS

The authors are grateful to Abbie Wall and Elise Walker for their assistance in collecting the data reported in this paper.

REFERENCES

[1] Nancy Doyle. 2020. Neurodiversity at work: a biopsychosocial model and the impact on working adults. Br. Med. Bull., 135, 1 (September 2020), 108–125. https://doi.org/10.1093/bmb/ldaa021

[2] Anna Krzeminska, Robert D. Austin, Susanne M. Bruyère, and Darren Hedley. 2019. The advantages and challenges of neurodiversity employment in organizations. J. Manag. Organ., 25, 4 (July 2019), 453-463. https://doi.org/10.1017/jmo.2019.58

[3] Lorelei A. Ortiz. 2020. Reframing neurodiversity as competitive advantage: Opportunities, challenges, and resources for business and professional communication educators. Bus. Prof. Commun. Q., 83, 3 (July 2020), 261–284. https://doi.org/10.1177/2329490620944456

[4] Anne Castles and Naama Friedmann. 2014. Developmental dyslexia and the phonological deficit hypothesis. Mind Lang, 29, 3 (June 2014), 270-285. https://doi.org/10.1111/mila.12050

[5] Mark Brosnan, James Demetre, Stephen Hamill, Kate Robson, Haidee Shepherd, and Gerard Cody. 2002. Executive functioning in adults and children with developmental dyslexia. Neuropsychologia, 40, 12 (2002), 2144-2155. https://doi.org/10.1016/s0028-3932(02)00046-5

[6] James H. Smith-Spark, Lucy A. Henry, David J. Messer, Elisa Edvardsdottir, and Adam P. Zięcik. 2016. Executive functions in adults with developmental dyslexia. Res. Dev. Disabil., 53-54 (June-July 2016), 323-341. https://doi.org/10.1016/j.ridd.2016.03.001

[7] Pamela Varvara, Cristiana Varuzza, Anna C. P. Sorrentino, Stefano Vicari, and Deny Menghini. 2014. Executive functions in developmental dyslexia.

Front. Hum. Neurosci., 8, (March 2014). https://doi.org/10.3389/fnhum.2014.00120

[8] Deny Menghini, Alessandra Finzi, Giovanni A. Carlesimo, and Stefano Vicari (2011). Working memory impairment in children with developmental dyslexia: Is it just a phonological deficity? Dev. Neuropsychol., 36, 2 (February 2011), 199-213. https://doi.org/10.1080/87565641.2010.549868

[9] Serena Provazza, Anne-Marie Adams, David Giofrè, and Daniel J. Roberts. 2019. Double trouble – visual and phonological impairments in English dyslexic readers. Front. Psychol., 10, (December 2019), Article 2725. https://doi.org/10.3389/fpsyg.2019.02725

[10] James H. Smith-Spark and John E. Fisk. 2007. Working memory functioning in developmental dyslexia. Memory, 15, 1 (January 2007), 34-56. https://doi.org/10.1080/09658210601043384

[11] David McLoughlin, Gary Fitzgibbon, and Vivienne Young. 1994. Adult dyslexia: Assessment, counselling and training. Whurr, London, UK.

[12] Joost de Beer, Josephine Engels, Yvonne Heerkens, and Jac van der Klink. 2014. Factors influencing work participation of adults with developmental dyslexia: a systematic review. BMC Public Health, 14, (January 2014), 77. https://doi.org/10.1186/1471-2458-14-77

[13] Nancy Doyle and Almuth McDowall. 2015. Is coaching an effective adjustment for dyslexic adults? Coaching, 8, 2 (August 2015), 154-168. https://doi.org/10.1080/17521882.2015.1065894

[14] Nancy E. Doyle and Almuth McDowall. 2019. Context matters: A review to formulate a conceptual framework for coaching as a disability accommodation. PLoS One, 14, 8 (August 2019), e0199408. https://doi.org/10.1371/journal.pone.0199408

[15] James H. Smith-Spark. 2018. A review of prospective memory impairments in developmental dyslexia: Evidence, explanations, and future directions. Clin. Neuropsychol., 32, 5 (July 2018), 816-835. https://doi.org/10.1080/13854046.2017.1369571

[16] Carol Leather, Henriette Hogh, Ellen Seiss, and John Everatt. 2011. Cognitive functioning and work success in adults with dyslexia. Dyslexia, 17, 4 (November 2011), 327-338. https://doi.org/10.1002/dys.441

[17] Karen Illingworth. 2005. The effects of dyslexia on the work of nurses and healthcare assistants. Nurs Stand, 19, 38 (June 2005), 41–48. https://doi.org/10.7748/ns2005.06.19.38.41.c3880

[18] David K. Morris and Patricia A. Turnbull. 2007. The disclosure of dyslexia in clinical practice: Experiences of student nurses in the United Kingdom. Nurse Educ Today, 27, 1 (January 2007), 35-42. https://doi.org/10.1016/j.nedt.2006.01.017

[19] Diana Bartlett, Sylvia Moody, and Katherine Kindersley. 2010. Dyslexia in the workplace. Wiley-Blackwell, Chichester, W. Sussex, UK.

[20] Vicki Goodwin and Bonita Thomson. 2012. Making dyslexia work for you (2nd ed.). Routledge, Abingdon, Oxon, UK.

[21] Margaret Malpas. 2012. Dyslexia in the workplace. British Dyslexia Association, UK.

[22] Sam J. Gilbert and Paul W. Burgess. 2008. Executive function. Curr. Biol., 18, 3 (February 2008), R110-R114. https://doi.org/10.1016/j.cub.2007.12.014

[23] Akira Miyake, Naomi P. Friedman, Michael J. Emerson, Alexander H. Witzki, Amy Howerter, and Tor D. Wager. 2000. The unity and diversity of executive functions, and their contributions to complex "frontal lobe" tasks: A latent variable analysis. Cogn. Psychol., 41, 1 (August 2000), 49-100. https://doi.org/10.1006/cogp.1999.0734

[24] Heidi A. Cramm, Terry M. Krupa, Cheryl A. Missiuna, Rosemary M. Lysaght, and Kevin H. Parker. 2013. Executive functioning: A scoping review of the occupational therapy literature. Canadian Journal of Occupational Therapy, 80, 3 (June 2013), 131-140. https://doi.org/10.1177/0008417413496060

[25] James H. Smith-Spark and Rebecca Gordon. 2022. Automaticity and executive abilities in developmental dyslexia: A theoretical review. Brain Sci, 12, 4 (March 2022), 446. https://doi.org/10.3390/brainsci12040446

[26] Eugene Winograd. 1988. Some observations on prospective remembering. In M. M. Gruneberg, P. E. Morris, and R. N. Sykes (Eds.), Practical aspects of memory: Current research and issues (Vol. 1, pp. 348-353). Wiley, Chichester, UK.

[27] Gilles O. Einstein and Mark A. McDaniel. 1996. Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In Maria Brandimonte, Gilles O. Einstein, and Mark A. McDaniel (Eds.), Prospective memory: Theory and application (pp. 115–141). Lawrence Erlbaum Associates, Mahwah, NJ, USA.

[28] Judi Ellis (1996). Prospective memory or realization of delayed intentions: A conceptual framework for research. In Maria Brandimonte, Gilles O. Einstein, and Mark A. McDaniel (Eds.), Prospective memory: Theory and applications (pp. l-23). Lawrence Erlbaum Associates, Mahwah, NJ, USA.

[29] Gene A. Brewer, Richard L. Marsh, Arlo Clark-Foos, J. Thadeus Meeks, Gabriel I. Cook, and Jason L. Hicks. 2011. A comparison of activity-based to event-based prospective memory. Appl. Cognit. Psychol., 25, 4 (July 2011), 632-640. https://doi.org/10.1002/acp.1733

[30] Mike Martin, Matthias Kliegel, and Mark A. McDaniel. 2003. The involvement of executive functions in prospective memory performance of adults. International Journal of Psychology, 38, 4 (August), 195-206. https://doi.org/10.1080/00207590344000123

[31] Mark A. McDaniel and Gilles O. Einstein. 2000. Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. Appl. Cognit. Psychol., 14, 7 (March 2000), S127–S144. https://doi.org/10.1002/acp.775

[32] Lia Kvavilashvili and Judi Ellis. 1996. Varieties of intention: Some distinctions and classifications. In Maria Brandimonte, Gilles O. Einstein, and Mark A. McDaniel (Eds.), Prospective Memory: Theory and Applications (pp. 23-52). Lawrence Erlbaum Associates, Mahwah, NJ, USA.

[33] David Shum, Gabor S. Ungvari, Wai-Kwong Tang, and Jin Pang Leung. 2004. Performance of schizophrenia patients on time-, event-, and activity-based prospective memory tasks. Schizophr. Bull., 30, 4 (January), 693-702. https://doi.org/10.1093/oxfordjournals.schbul.a007123

[34] Gilles O. Einstein, Mark A. McDaniel, Richardson, S. L., Guynn, M. J., and Cunfer, A. R. 1995. Aging and prospective memory: Examining the influences of self-initiated retrieval processes. Journal of Experimental Psychology: Learning, Memory, and Cognition, 21, 4 (July 1995), 996-1007. https://doi.org/10.1037/0278-7393.21.4.996

[35] Mark A. McDaniel and Gilles O. Einstein. 2007. Prospective memory: An overview and synthesis of an emerging field. Sage Publications, Thousand

Oaks, CA, USA. https://dx.doi.org/10.4135/9781452225913

[36] Shayne Loft, Key Dismukes, and Tobias Grundgeiger. 2021. Prospective memory in safety-critical work contexts. In Jan Rummel and Mark A. Daniel (Eds.), Prospective memory. Routledge, Abingdon, Oxon, UK. https://doi.org/10.4324/9781003106715

[37] Abigail J. Sellen, G. Louie, J.E. Harris, and A.J. Wilkins. 1997. What brings intentions to mind? An in situ study of prospective memory, Memory, 5, 4 (July 1997), 483-507. https://doi.org/10.1080/741941433

[38] R. Key Dismukes. 2012. Prospective memory in workplace and everyday situations. Curr. Dir. Psychol. Sci., 21, 4 (July 2012), 215–220. https://doi.org/10.1177/0963721412447621

[39] Shayne Loft. 2014. Applying psychological science to examine prospective memory in simulated air traffic control. Curr. Dir. Psychol. Sci., 23, 5 (October 2014), 326–331. https://doi.org/10.1177/0963721414545214

[40] Nikita Sharma, Azizuddin Khan, and Jai Prakash Kushvah. 2020. Role of prospective memory in driving behaviour. Trans. Res. Proc., 48, 1 (2020), 1334-1341. https://doi.org/10.1016/j.trpro.2020.08.162

[41] Tobias Grundgeiger, P.M. Sanderson, C.B. Orihuela, A. Thompson, H.G. MacDougall, L. Nunnink, and B. Venkatesh, B. 2013. Prospective memory in the ICU: the effect of visual cues on task execution in a representative simulation. Ergonomics, 56, 4 (March 2013), 579–589. https://doi.org/10.1080/00140139.2013.765604

[42] Tobias Grundgeiger, Penelope M. Sanderson, and R. Key Dismukes. 2014. Prospective memory in complex sociotechnical systems. Z. Psychol., 222, 2 (2014), 100–109. https://doi.org/10.1027/2151-2604/a000171

[43] James H. Smith-Spark, Adam P. Zięcik, and Christopher Sterling. 2016. Self-reports of increased prospective and retrospective memory problems in adults with developmental dyslexia. Dyslexia, 22, 3 (August 2016), 245-262. https://doi.org/10.1002/dys.1528

[44] James H. Smith-Spark, Adam P. Zięcik, and Christopher Sterling. 2017. Adults with developmental dyslexia show selective impairments in time-based and self-initiated prospective memory: Self-report and clinical evidence. Res. Dev. Disabil., 62, (March 2017), 247-258. https://doi.org/10.1016/j.ridd.2016.12.011

[45] James H. Smith-Spark, Adam P. Zięcik, and Christopher Sterling. 2016. Time-based prospective memory in adults with developmental dyslexia. Res. Dev. Disabil., 49-50, (February-March 2016), 34-46. https://doi.org/10.1016/j.ridd.2015.11.006

[46] James H. Smith-Spark, Adam P. Zięcik, and Christopher Sterling. 2017. The event-based prospective memory of adults with developmental dyslexia under naturalistic conditions. Asia Pacific Journal of Developmental Differences, 4, 1 (January 2017), 17-33. https://doi.org/10.3850/S2345734117000036

[47] Ashok S. Jansari, Alex Devin, Rob Agnew, R., Katarina Akesson, Lesley Murphy, and Tony Leadbetter. 2014. Ecological assessment of executive functions: A new virtual reality paradigm. Brain Impairment, 15, 2 (/September 2014), 71-87.

[48] Anita Condor, Vicki Anderson, and Michael Saling. 1995. Do reading disabled children have planning problems? Dev. Neuropsychol., 11, 4 (1995) 485-502. https://doi.org/10.1080/87565649509540633

[49] C. Klicpera. 1983. Poor planning as a characteristic of problem behavior in children with dyslexia. Acta Paedopsychiatr., 49, 1-2 (May 1983), 73–82.

[50] Bonnie E. Levin. 1990. Organizational deficits in dyslexia: Possible frontal lobe dysfunction. Dev. Neuropsychol., 6, 2 (1990) 95-110. https://doi.org/10.1080/87565649009540453

[51] David Galbraith, Veerle Baaijen, Jamie Smith-Spark, and Mark Torrance. 2012. The effects of dyslexia on the writing processes of students in higher education. In Mark Torrance, Denis Alamargot, Montserrat Castelló, Franck Ganier, Otto Kruse, Anne Mangen, Liliana Tolchinsky, and Luuk van Waes (Eds.), *Learning to Write Effectively: Current Trends in European Research* (pp. 195-198). Brill Books Online, Leiden, The Netherlands. https://doi.org/10.1163/9781780529295_044

[52] Tilly Mortimore and W. Ray Crozier. 2006. Dyslexia and difficulties with study skills in higher education. Stud. High. Educ., 31, 2 (January 2006), 235-251. https://doi.org/10.1080/03075070600572173

[53] Dorothy E. Gilroy and Tim R. Miles. 1996. Dyslexia at college (2nd Edition). London: Routledge.

[54] Donald A. Norman and Tim Shallice. 1986. Attention to action: Willed and automatic control of behaviour. In R. J. Davidson, G. E. Schwartz, and D. Shapiro (Eds.), Consciousness and self-regulation: Advances in research and theory. Vol.4. (pp. 1-18). Plenum Press, New York, USA.

[55] Angela J. Fawcett and Roderick I. Nicolson. 1998. The Dyslexia Adult Screening Test (DAST). The Psychological Corporation, London, UK.

[56] David Wechsler (1993). The Wechsler Objective Reading Dimensions. The Psychological Corporation, London, UK.

[57] Ashok Jansari, Rob Agnew, Katarina Akesson, and Lesley Murphy. 2004. Using virtual reality to create an ecologically-valid measure of real-world problems in patients with dysexecutive syndrome. Brain Impairment, 5, 96–116.

[58] James H. Smith-Spark, Lucy A. Henry, David J. Messer, and Adam P. Zięcik. 2017. Verbal and non-verbal fluency in adults with developmental dyslexia: Phonological processing or executive control problems? Dyslexia, 23, 3 (August 2017), 234-250. https://doi.org/10.1002/dys.1558

5 HISTORY DATES

Received April 2022; revised June 2022; accepted XXXX 2022