



Distinct Effects of Executive Functioning, Impulsivity and Anxiety on Global and Local Reading Comprehension

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Reading comprehension (RC) is a cognitive ability linked with higher-order cognitive functions referred to as executive functions (EFs) and is also associated with educational achievement. To date, there is little research exploring links between reading comprehension, EFs, and personality traits. This study attempts to fill this gap by elucidating the role of EFs, trait impulsivity, and trait anxiety in RC among university students. To achieve a more in-depth examination, RC is divided into its global and local subskills. Ninety university students (83% female) completed self-report questionnaires on EFs, impulsivity, and anxiety, a neuropsychological task for cognitive flexibility, and global/local RC assessments. Our results indicated distinct associations between poor general EFs and poor global RC, poor cognitive flexibility and poor local RC, and, finally, between high impulsivity and adequate global RC. Individual differences in global and local information processing strategies in the context of attentional processes and personal traits of the university students, is discussed.

Keywords: reading comprehension, executive functions, cognitive flexibility, impulsivity, anxiety, global/local information processing

OPEN ACCESS

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Specialty section:

This article was submitted to
Educational Psychology,
a section of the journal
Frontiers in Education

Received: 25 July 2021

Accepted: 08 November 2021

Published: 13 December 2021

Citation:

Leshem R and Altman C (2021)
Distinct Effects of Executive
Functioning, Impulsivity and Anxiety on
Global and Local
Reading Comprehension.
Front. Educ. 6:746978.
doi: 10.3389/feduc.2021.746978

INTRODUCTION

Reading comprehension (RC) is considered a cognitive ability closely related to executive functions (EFs) (Follmer, 2018; Nouwens et al., 2021). EFs are a set of higher-order cognitive functions consisting of three key components—working memory, inhibition, and cognitive flexibility—from which more complex and higher-order EFs are built (e.g., reasoning and planning) (Miyake et al., 2000; Diamond, 2013). EFs are essential for controlling unregulated behaviors including impulsive and anxious behaviors (Snyder et al., 2019; Buzzell et al., 2020; Friedman et al., 2020). Note, the multidimensional nature of EFs raises complexity regarding its theoretical conceptualization. This complexity is particularly pronounced in the examination of the relationship between EFs and other multidimensional constructs, such as anxiety and impulsivity. It is particularly evident in the examination of latent components of EFs (e.g., shifting, inhibition) in relation to impulsivity and/or anxiety. That is, the convergent and discriminant validity of these constructs is not clear, and the nature of their differences remains to be determined. However, based on the conceptualizations of common unity and diversity models of EFs (Miyake et al., 2000; Miyake and Friedman, 2012; Friedman and Miyake, 2017; Zelazo and Müller, 2002), growing evidence suggests relationships

between impulsivity and anxiety traits and EFs, among them cognitive flexibility (Kenemans et al., 2005; Eysenck et al., 2007; Bickel et al., 2012; Pacheco-Unguetti et al., 2012; Leshem, 2016a; Shields et al., 2016; Friedman et al., 2020; Wegmann et al., 2020; Warren et al., 2021), which is the ability to shift between multiple tasks or mental strategies (Miyake and Friedman, 2012; Zelazo, 2015). Research has shown that individuals with high impulsivity or anxiety experience difficulties in EFs, including cognitive flexibility (Edwards et al., 2015; Müller et al., 2015; Leshem, 2016b; Leshem, 2018; Park and Moghaddam, 2017).

Impulsivity and anxiety are also linked to RC (Follmer, 2018; Miller et al., 2020; Tynan et al., 2020), which plays a crucial role in educational and professional success of university students (Sadeghi et al., 2012). A deeper understanding of these rarely researched associations is needed. Indeed, two separate bodies of research relate to this enquiry: one linking EFs to language skills and another linking EFs to impulsive and anxious behavior regulation. To date, there has been no explicit attempt to link the evidence between these two interdisciplinary paradigms. This study aims to fill this gap by elucidating the role of EFs and impulsive and anxiety traits in RC among university students.

THE READING COMPREHENSION LINK TO EXECUTIVE FUNCTIONING

Reading comprehension is integral to learning processes (Fiorella and Mayer, 2016; Barnes et al., 2020). It involves knowledge of relevant vocabulary, background information, grammatical formulations, metaphorical language, and inferential reasoning—all of which must be applied in a coordinated manner to adequately comprehend written text (Sesma et al., 2009). Thus, RC as a multifaceted, complex skill comprised of subskills and cognitive processes acting in concert (e.g., encoding, instantiation, inference, retrieval), and related to integration, planning, editing, summarizing, and reconstructive processes (Butterfuss and Kendeou, 2018; Cutting et al., 2009; Meixner et al., 2019; Pazeto et al., 2014; Sesma et al., 2009). The interplay of these subskills requires cognitive functions including updating, focused attention, shifting of attention, and inhibition of irrelevant text information (Cutting et al., 2009; Follmer, 2018).

Much previous research has focused on EF effects on RC, in particular as assessed during preschool and primary school (Meltzer, 2018; Meixner et al., 2019; Spencer et al., 2020; Nouwens et al., 2021), showing that EF deficits are related to RC difficulties (see Cutting et al., 2009; Engel de Abreu et al., 2014). s (Huizinga and Smidts, 2010; Georgiou and Das, 2018; Follmer and Sperling, 2019). Specifically, in typical development, reading abilities are expected to improve as a function of age, in part because of the developmental course of EFs—from a more “unitary” construct in early childhood to a multi-faceted construct in adulthood (Georgiou and Das, 2018; Ober et al., 2019) consisting of lower-level components (e.g., WM, inhibition, cognitive flexibility) and higher-level components (e.g., reasoning, problem solving, and planning). Accordingly, EFs have been found to make unique contributions to RC at different grade levels and ages, from preschool children to

adult learners (Potocki et al., 2017). It has been demonstrated that, in addition to word decoding and language skills, EFs help explain the significant variance in RC seen in the upper grades of primary school; indeed, several longitudinal studies documented that the contribution of EFs to reading comprehension increases in the upper primary grades when decoding skills are more developed (Nouwens et al., 2021). In essence, the examination of the relationship between EFs and RC is important as skilled adult readers must flexibly coordinate multiple aspects of reading tasks for successful comprehension which requires integration of information across multiple paragraphs, inhibition of irrelevant information, and monitoring of comprehension (Georgiou and Das, 2018). As skilled adult readers, reading speed and consequently RC speed is expected to be intact since both speed and accuracy underlie RC skills (Juul et al., 2014).

This corresponds with the various models that conceptualize RC through lower-level reading processes (e.g., Simple View of Reading) to higher-level reading processes (e.g., the lattice model, structure-building framework), reflecting the contribution of EF components to RC processes (see Haft et al., 2019 for further reading). Furthermore, compared to research on updating and inhibition, relatively little research exists on the relationship between shifting functions—a central part of cognitive flexibility—and RC (Butterfuss and Kendeou, 2018). Indeed, successful RC depends on cognitive flexibility by enabling focus shifting from word-level processing to overall text meaning (Butterfuss and Kendeou, 2018; Follmar, 2018).

Researchers have investigated the contributions of EFs to reading comprehension beyond the skills of decoding (Follmer, 2018). For example, inferencing and selective attention to specific parts of the text increase attentional resources which subsequently facilitate the development of comprehension (Reynolds, 1992, 2000). Even if not explicitly indicated, the importance of the role of EFs have been acknowledged in reading comprehension models (see Butterfuss and Kendeou, 2018 for a review). One such example may be taken from The Structure-Building Framework (Gernsbacher, 1991) which depicts comprehension as the result of three processes: laying foundation (using information from the text to base a mental representation), mapping (finding text information to build structures) and shifting (allocating to a different structure when unable to map to an existing structure). The shifting, which leads to suppression, may account for individual differences in which skilled readers know whether and when to suppress information while less-skilled readers do not.

Moreover, the distinction between RC's global and local subskills should be considered, as they rely on different perceptual organization and attentional processes (i.e., attentional bias to focus on small local or global information; Chamberlain et al., 2017). Global perceptual processing has been suggested as abstraction “reflecting a construal or meaning-making process whereby individuals distill the essence or gist of some stimulus” (Darwent et al., 2010, pp 199) and is presumed to require a broader focus of attention (i.e., more spatially distributed attentional scope). In contrast, local processing, has been associated with a smaller

focus of attention (Hagenaars et al., 2016). It should be noted that many studies have focused on English as the target language and therefore may be less generalizable to other languages such as Hebrew in the current study.

GLOBAL AND LOCAL STRATEGIES IN RC

Fuzzy-trace theory (FTT, Reyna, 2012), a comprehensive, dual-process model of information perception, posits two types of representations of a written stimulus that are encoded in memory: verbatim representation, capturing the text's exact words, numbers, or images, and gist representation, capturing essential "bottom-line" meaning (Reyna, 2012; Blalock and Reyna, 2016). Both verbatim and gist information-based representations are indicative of different language skills/techniques, termed "local comprehension" and "global comprehension." To read and answer questions about a text, one must distinguish between global and local main ideas. Following (Wang, 2009), the local main idea is derived from the sentence level while the global main idea is derived from the overarching text level (Meyer, 2003). Similarly, Follmer (2018) offers that local cohesion refers to the sentence level (in which pieces of information overlapping between sentences in close proximity are needed for synthesis), while global cohesion refers to the overarching text level (in which information overlapping whole sections or the totality of the text are needed for synthesis). Thus, global comprehension is the notion of understanding a text in its entirety. It requires greater proficiency identifying the general overall meaning, rather than specific details (Cartwright, 2009). In contrast, local comprehension is detail-intensive reading to extracting specific information (Aragon et al., 2002; Cartwright, 2009; Israel and Duffy, 2009; Shi, 2011).

Individual differences are seen in global or local information processing, with personality differences seeming to induce different perceptual styles. Some studies suggest a local/global bias as a general personality trait (de-Wit and Wagemans, 2015); for example, trait-anxious individuals show relative preference for local processing during negative states (Derryberry et al., 1998; Hagenaars et al., 2016; Shilton et al., 2019; Veerapa et al., 2020) and attentional narrowing (focused attention) is related to anxiety and emotion intensity. In contrast, impulsive individuals tend to adopt a broad attentional scope, especially in emotionally arousing situations (Patton et al., 1995; Uncapher et al., 2016).

THE READING COMPREHENSION LINK TO IMPULSIVITY AND ANXIETY TRAITS

Classification of RC into global and local subskills is also found in personality literature as "a holistic dimension" (Peterson and Deary, 2006; Milne and Szczerbinski, 2009), a pattern emerging from combining local and global elements. Accordingly, *processing* information takes place at the global (broad) level, while *organizing* detailed information takes place at the local (detailed) level. Further, evidence suggests global/local RC may be oriented toward certain personality traits: impulsive individuals

seem to possess a more global focus and anxious individuals a more local focus (Becker et al., 2018; Dickman, 1985; Rivers et al., 2008).

Notwithstanding, both impulsivity and anxiety personality traits may manifest due cognitive ability deficits (e.g., attentional control) that may, in turn, affect RC competence. Individuals with impulsive tendencies may rapidly process information and quickly respond with little forethought, sometimes hindering academic performance (Vigil-Colet and Morales-Vives, 2005). Indeed, absence of reflection between stimulus and response, as occurs with impulsivity, may prevent maintaining focus during reading; this may occur due to distraction or particularly speedy processing. Note, some studies suggest that consequences of impulsivity are not always negative and may even be advantageous depending on cognitive demands of a task, such as the degree of difficulty, complexity, cognitive load, and time limit (Claes et al., 2000; Dickman, 2000; Eysenck et al., 2007; Eysenck and Derakshan, 2011; Leshem, 2018). Trait anxiety is linked to multiple cognitive processes important for adequate RC skills, including directing attention and cognitive resources toward achieving one's goals (Fales et al., 2008; Grant and White, 2016; Raymond et al., 2017; Jaiswal et al., 2018). Much anxiety research has focused on distracting effects of worry, anxiety disorder, and threat-related attentional biases, especially in the context of academia (i.e., test anxiety) (Bar-Haim et al., 2007; Brandt et al., 2020; Gustavson et al., 2019; Macher et al., 2012; Moser et al., 2013; Tysinger et al., 2010). Bearing in mind that although trait anxiety may predispose individuals to develop anxiety disorder or threat-induced state anxiety, anxiety as a stable personality trait should be distinctive in terms of its underlying biopsychological mechanisms and its possible effects (positive or negative) on different cognitive-performance tasks (Bishop, 2008; Eysenck et al., 2007; Raymond et al., 2017; Robinson et al., 2013; Saviola et al., 2020; Vytal et al., 2012, 2013).

THE PRESENT STUDY

This study attempts to elucidate the role of EFs and specific personality traits-impulsivity and anxiety-in global and local RC subskills. EF evaluation consisted of a behavioral rating of daily EFs (higher-order cognitive functions such as behavioral regulation and metacognition). Considering the multidimensional nature of EFs, as well as impulsivity and anxiety, we used validated instruments to measure trait impulsivity and anxiety and we used a validated self-report questionnaire to measure EFs (BRIEF-A; e.g., Gioia and Isquith, 2004; Olsson et al., 2020; Toplak et al., 2013). Because these are context-dependent, multivariate constructs, such that different forms of impulsive or anxiety behavior and EFs are influenced by different situational and cognitive processes, using self-report measures of personality traits in addition to the BRIEF-A (Roth et al., 2013; Baars et al., 2015; Rike et al., 2015; Friedman et al., 2016; Lantrip et al., 2016) is relevant to obtaining a comprehensive understanding of how they separately relate to RC subskills. In addition, a neuropsychological

performance task assessed cognitive flexibility through analyzing response perseveration and error recurrence, as preservative errors vary among individuals with impulsivity and/or anxiety (Bishara et al., 2010) and may not be captured in standard behavioral ratings of daily EFs. Thus, both types of EF measurements may tap into related, yet separate, constructs (Dajani and Uddin, 2015; Miranda et al., 2015).

Accordingly, we predicted that adequate general EFs, measured by the daily EF behavior rating, would be associated with good performance in global and local RC. We further predicted that cognitive flexibility, measured by the neuropsychological performance task, would influence RC skills on the local, but not global, level. Since research into the relationship between personality traits and RC is scant, if any connection were found between RC subskills and personality traits, we expected that high impulsivity would be associated with better global skills and high anxiety would be associated with better local skills.

MATERIALS AND METHODS

Participants

Ninety undergraduate university students enrolled a course in the social sciences (75 females; $M_{\text{age}} = 22.84$; age range: 19–29 years) participated in this study voluntarily. All participants rated their Hebrew competence in speaking, understanding, reading, and writing on a 5-point scale. Those indicating a learning disorder ($n = 4$) and/or being bilingual ($n = 2$) were excluded, as this study focused on monolingual typically-reading adults (namely, the originally-recruited cohort totaled 96). No history of neurological, psychiatric illnesses, language-related disorders, including attention deficit hyperactivity disorder, was reported. The sample size was determined based on commonly used rule of thumb recommended for linear regression analysis based on predictor variables (Green, 1991). We conducted a post-hoc test to determine the static power of the current sample using G*Power 3.0.10 (Faul et al., 2007; Faul et al., 2009). It was found that using 90 participants and a linear multiple regression of a fixed model, R^2 deviation from zero design with three predictors, an a-priori α of 0.05 and a medium effect size, we could detect effects of power that equals to 0.87. This effect size exceeds the accepted 0.80 in the literature (MacCallum et al., 1996). The study was approved by the university's human subject protection Institutional Review Board (i.e., Helsinki committee) and all participants provided signed informed consent.

Measures

Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995) consists of 30 items scored on a 4-point scale (1 = rarely/never to 4 = always) including three subscales: motor, attentional, and non-planning. The BIS-11 provides a total score serving as a global impulsivity measure, ranging from 30 to 120. A total score between 52 and 71 is considered within normal limits for impulsiveness. A total score of ≥ 72 is used to classify an individual as highly impulsive (Stanford et al., 2009). A validated translation to Hebrew (Glicksohn and Nahari, 2007;

Leshem and Glicksohn, 2007; Leshem, 2016b; Leshem and Yefet, 2019) was utilized and had adequate reliability ($\alpha = 0.72$).

State-Trait Anxiety Inventory-Trait Anxiety (STAI-TA; Spielberger et al., 1983) includes 20 items on a 4-point scale (1 = Not at all to 4 = Very much so). The STAI-TA score varies from 20 to 80. STAI scores are commonly classified as “no or low anxiety” (20–37), “moderate anxiety” (38–44), and “high anxiety” (45–80). A validated translation to Hebrew (Leshem, 2018) was utilized and had adequate reliability ($\alpha = 0.89$).

Behavior Rating Inventory of Executive functions- Adult version (BRIEF-A, Roth, Isquith, and Gioia, 2005) contains 75 items scored on a 3-point scale (higher scores indicate poorer executive function) and two index scores: Behavioral Regulation Index and Metacognition Index. The Behavioral Regulation index is comprised of four scales (Inhibition, Shifting, Emotional Control, and Self-Monitoring) and the Metacognition Index is comprised of five scales (Initiation, Working Memory, Planning/Organization, Task Monitoring, and Organization of Materials). The BRIEF-A provides a total score that serves as a general index of EFs, and ranges from 75 to 225, with higher scores indicating greater impairment. For clinical evaluation, a T-score is calculated for each scale, in which a total score of < 65 signifies clinical impairment. A validated translation to Hebrew was utilized (Sharfi, and Rosenblum, 2016; Stern et al., 2017) in the current study and had adequate reliability ($\alpha = 0.94$).

The *Wisconsin Card Sorting Task-computerized version* (WCST: Heaton et al., 1993; Leshem and Glicksohn, 2007) is a neuropsychological test for assessing cognitive flexibility, and includes adaptation to changes in task contingencies and set-shifting (Smillie et al., 2009; Bishara et al., 2010; Gray-Burrows et al., 2019). In this computerized version, participants are presented four sample cards, each with geometric designs that vary along three dimensions: color, shape, and number. Participants sequentially pick a card from a pre-sorted deck of 64. Instructions are given to match each card to one of the sample cards, with the goal to get as many correct matches as possible. Participants decide whether the (unknown) criterion for matching cards on that trial relates to color, shape, or number; feedback is given after each trial. After 10 consecutive correct matches are made, the criterion for matching is switched. This is repeated with a second deck of cards in the same order. Previous studies demonstrated equivalence in validity between the manual test and the computer-based version used in this study (Wagner and Trentini, 2009; Çelik et al., 2021).

Reading Comprehension Tests

The RC questions were constructed by the Israeli National Institute for Testing and Evaluation and are directly linked to thinking methods that are required in different academic studies. These questions solicit specific details from a complex text and aim to arrive at conclusions by examining the internal logic underlying the assumptions and sets of logical rules. For example, the ability to understand complex claims is needed in the field of psychology and economics. The ability to complete sentences requires comprehension at the sentence level, which is based on understanding content words (e.g., nouns, verbs) and function words (e.g., prepositions, conjunctions); this ability is needed in

academic studies. Three short academic texts were chosen for participants to read and then answer 16 comprehension questions. There were two texts followed by 5 questions and one text followed by 6 questions. Questions included information related to details explicitly provided in the text, reference questions, and conclusive questions that required implicit understanding. Multiple-choice questions were divided into globally-oriented (7) and locally-oriented (9) questions. Global question examples were: “Why is it difficult for us to direct someone?”; “The sentence “I decided to do something and so I did it” is brought in the text as an example of. . .”, and “What is the meaning of “Theory of mind?”” In contrast, a local question example was: “According to the text, “negligence” means. . .” Each correct answer received one point with a maximum score of 16. The Psychometric Entrance Test (PET) used for admission to higher education in Israel consists of three timed sections. The reading comprehension questions used in this study (primarily represented by multiple-choice [MC] questions) examine verbal skills and analysis, and comprehension of complex written text. They require one to think clearly and systematically, and to perceive fine distinctions between word and concept meanings. All the PET test components (the verbal domain among them) were consistently found to have high validity (Oren et al., 2014; Allalouf et al., 2020).

Procedure

Participants were tested individually in a quiet room, completing the tests in one session lasting approximately 1 hour. First, they completed the computerized task—the WCST. Next, they completed the three language comprehension tests; their order was randomized across participants. Finally, they were asked to complete the self-report personality measures for impulsivity and anxiety (BIS-11 and STAI-TA, respectively) and the BRIEF-A for assessment of general EFs. Self-report questionnaires were presented in a counterbalanced order.

Statistical Analysis

SPSS™ version 25 was used for statistical analysis. Four indices of predictors were calculated. Two were: the daily EF behavioral rating (BRIEF-A total score—high scores indicative of poor general EFs), and cognitive flexibility [labeled as WCST Lg10(PE); calculated as the log transformation of the number of perseverative errors on the Wisconsin Card Sorting Task, involving continued use of a criterion that would be correct if the immediately preceding criterion continued]. The other two predictors, the impulsive and anxious personality trait indices, were calculated by the total scores on the BIS-11 and STAI-TA, respectively.

To evaluate the outcome measure, RC, a distinction between the Language Comprehension Test’s global and local reading comprehension questions was made by three raters. The raters were asked to determine which questions measured global skills and which measured local skills. Interrater reliability was 87.5 and discrepancies were discussed with a third rater to reach a unified final decision. Separate scores were calculated for local and global RC. The local comprehension score was calculated by dividing the number of correct local questions by 7, resulting in the total local

score. The global comprehension score was calculated by dividing the number of correct global questions by 9, resulting in the total global score.

First, Spearman correlations were conducted to examine correlations between the variables. Then, hierarchical regression analyses were conducted with global and local RC as the outcome variables (y). Each regression equation had two steps whereby the variables of BRIEF-A (general EFs) and WCST Lg10(PE) (cognitive flexibility) were entered as independent variables (x) in the first step and personality traits (impulsivity and anxiety) in the second step. Overall, four regression models exhibited the full model statistics for each model estimated. As recommended by Preacher and Hayes (2008), we used a bootstrapping method effective with this sample size and least vulnerable to Type I errors. Bootstrapping does not assume normal distributions and is also a nonparametric resampling procedure appropriate for this sample. We resampled the data 10,000 times as recommended by Hayes (2013).

RESULTS

Data Screening

Initial screening of the data for normality was conducted by testing the significance of skewness and kurtosis of the distributions for each measure, resulting in rejecting the assumption of normality for WCST(PE) and anxiety variables. In the WCST task, premature anticipatory responses with latencies shorter than 150 ms (Whelan, 2008) as well as responses with latencies more than three SD s above the sample mean, were excluded from the analyses. This resulted in the removal of two participants from the study, who were then replaced with two matching participants to maintain a sample of ninety participants. Performing descriptive statistic and regression analyses excluding the two participants prior to replacement yielded no change in the results. After removing two outliers with extreme values in the WCST, we retested the assumptions of normality in each variable. Due to violation of the assumption of normality for the WCST, we performed log transformations to normalize the distribution. In addition, anxiety and RC subskills measures showed non-normal distributions. As such, statistical analysis for non-normal distributions were used.

Descriptive statistics of variables and Spearman correlations are reported in **Table 1**. Local RC was positively correlated with global RC and negatively correlated with cognitive flexibility [WCST Lg10(PE)]. Also, there were positive correlations between anxiety and impulsivity traits (STAI-TA and BIS-11 scores, respectively), and general EFs (BRIEF-A). There were no other significant correlations ($r_s < 0.3$, $p > 0.1$).

The Effects of General EFs, Impulsivity, and Anxiety on Global and Local RC

The first regression model was significant, showing 5% of the variance in global RC was accounted for by general EFs in the

TABLE 1 | Descriptive statistics¹ and Spearman correlations for the research variables.

Variable	Range	M	SD	1	2	3	4	5	6	7
1. Local RC	0.64–1	0.91	0.08							
2. Global RC	0.70–1	0.93	0.07	0.23*						
3. BRIEF-A sum	77–155	106.97	18.26	0.02	-0.19					
4. BRIEF-A T-score	32.48–76.38	50	10							
5. WCST Lg(PE)	0.60–1.61	1.10	0.24	-0.22*	-0.14	0.06	0.07			
6. WCST PE sum	4–41	14.6	8.8							
7. STAI-TA	24–62	37.98	9.68	0.12	-0.03	0.59**	0.60**	0.15	0.15	
8. BIS-11	41–75	58.66	8.26	0.02	0.02	0.64**	0.62**	0.03	0.03	0.27**

Note: RC, reading comprehension; BRIEF-A, Behavior Rating Inventory of Executive Functions- Adult; BIS-11, Barratt Impulsiveness Scale; STAI-TA, State-Trait Anxiety Inventory—Trait Anxiety; WCST, Lg10(PE) = The Wisconsin Card Sorting Task log transformation of the number of perseverative errors; WCST(PE) = Untransformed perseverative errors.

¹The Means(SDs) for the variables after excluding the two participants prior to replacement (N = 88): Local RC = 0.91 (0.07); Global RC = 0.93 (0.07); BRIEF-A sum = 106.31 (17.86); WCSTLg(PE) = 1.09 (0.23); STAI-TA; 37.7 (9.6); BIS-11 = 58.6 (8.3)

base model, whereas, in the full model, approximately 11% of the variance in global RC was accounted for by general EFs, impulsivity, and anxiety. Specifically, a high general EF score predicted a low global RC score, with other effects held constant. Furthermore, as the impulsivity score increased, the global RC score increased as well, with other effects held constant (see **Table 2**).

In the second regression model, general EFs, impulsivity, and anxiety were not found significant predictors for local RC (see **Table 2**).

The Effects of Cognitive Flexibility, Impulsivity, and Anxiety on Local and Global RC

The third regression model showed no significant results; that is, cognitive flexibility and personality traits did not constitute significant predictors of global RC (see **Table 3**). However, the fourth regression model, which predicted local RC by examining the independent variables of cognitive flexibility [WCST Lg(PE)] and personality traits (BIS-11, STAI-TA), although not found significant, the effect of cognitive flexibility on local RC was found significant. Specifically, poor WCST performance predicted poor local RC, with other effects held constant. Impulsivity and anxiety were not found significant predictors of local RC (see **Table 3**).

DISCUSSION

This study examined the effects of general EFs, cognitive flexibility, and impulsivity and anxiety traits on local and global RC subskills among university students. The main findings indicated distinct effects of general EFs, cognitive flexibility and impulsivity, on global and local RC subskills. Results showed poor general EFs associated with poor global RC, and poor cognitive flexibility associated with poor local RC. Impulsivity was associated with better global RC performance, whereas anxiety showed no effect on local or global RC.

General Executive Functions and Cognitive Flexibility Link to Global and Local RC

The hypothesis regarding the association between adequate general EFs and good performance in global and local RC was partially supported, showing that general EFs abilities influence performance in global RC but not in local RC. Based on information processing strategies in RC, global and local questions require different processing demands. When asked a specific “local question” relating to a text, a particular set of cognitively flexible resources are recruited compared to a “global question” that taps into a general gist-based processing information strategy for text comprehension (Cartwright, 2009). This may explain the distinct effects of general EFs and cognitive flexibility on global and local RC performance. Specifically, our findings showed that difficulties in general EFs predicted poor global RC performance, suggesting that global reading presumably relies on more extensive EFs, such as working memory, metacognition, and reasoning, which one has to recruit in order to synthesize the pieces of text to arrive at the gist (Israel and Duffy, 2009; Nicolielo-Carrilho et al., 2018). In contrast, and in accordance with the hypothesis on the influence of cognitive flexibility on local RC, difficulties in cognitive flexibility predicted poor local RC performance, suggesting that cognitive flexibility is critical for RC at the word-sentence level (Cartwright, 2009; Colé et al., 2014; Follmar 2018). That is, local reading processing may rely more on cognitive flexibility that determines when, where, and in what manner particular processing strategies are used for a given situation (Kozhevnikov, 2007; Juntorn et al., 2017).

Furthermore, the markedly distinct findings between general EFs and cognitive flexibility suggest that cognitive flexibility is not merely the sum of implementing various EFs, but also requires shifting, or reconfiguration of one’s response set to a new goal (Dajani and Uddin, 2015). In RC, skilled “comprehenders” actively shift focus across several levels (i.e., shifting between micro- and macro-level text comprehension) (Butterfuss and Kendeou, 2018; Cartwright, 2015; Colé et al., 2014; Follmer, 2018; Kieffer et al., 2013). Our finding may support the claim that general EFs and cognitive flexibility should be treated differently because they tap into different processing

TABLE 2 | ¹Hierarchical regression model with global and local reading comprehension as the outcome variables and general EFs, impulsivity, and anxiety as independent variables.**Model 1: Outcome variable: Global reading comprehension**

Base model					Full model			
$R^2 = .05, F(1, 88) = 4.82, p = .03$					$R^2 = .11, F(3, 86) = 3.58, p = .02$			
					$\Delta R^2 = .06, F(2, 86) = 2.86, p = .06$			
Variable	b(se)	β	P	95%CI	b(se)	B	p	95%CI
BRIEF-A	-0.001 (0.00)	-0.23	0.03	[-0.002, 0.00]	-0.002 (0.00)	-0.51	0.002	[0.003, 0.001]
BIS-11					0.002 (0.001)	0.26	0.04	[0.00, 0.004]
STAI-TA					0.002 (0.001)	0.21	0.12	[-0.00, 0.004]
Constant	1.03 (0.05)		<0.001	[0.94, 1.12]	0.96 (0.05)		<0.001	[0.85, 1.06]

Model 2: Outcome variable: Local reading comprehension

Base model					Full model			
$R^2 = .002, F(1, 88) = .17, p = .68$					$R^2 = .04, F(3, 86) = 1.13, p = .34$			
					$\Delta R^2 = .036, F(2, 86) = 1.60, p = .21$			
Variable	b(se)	β	P	95%CI	b(se)	B	p	95%CI
BRIEF-A	0.00 (0.00)	-0.04	0.68	[-0.001, 0.001]	-0.001 (0.001)	-0.26	0.12	[-0.003, 0.000]
BIS-11					0.001 (0.001)	0.12	0.36	[-0.001, 0.004]
STAI-TA					0.002 (0.001)	0.23	0.10	[-0.00, 0.004]
Constant	0.93 (0.05)		<0.001	[0.83, 1.02]	0.89 (0.06)		<0.001	[0.77, 0.99]

Notes: BRIEF-A, Behavior Rating Inventory of Executive Functions- Adult version; BIS-11, Barratt Impulsiveness Scale; STAI-TA, State-Trait Anxiety Inventory—Trait Anxiety.

¹Regression analyses excluding the two participants and prior to replacement. Model 1: Regression model with global reading comprehension as the outcome variable. Base model: $R^2 = .05, F(1, 86) = 5.02, p = .03$. Full model: $R^2 = .11, F(3, 84) = 5.02, p = .02$. $\Delta R^2 = .06, F(2, 84) = 2.60, p = .08$. Model 2: Regression model with local reading comprehension as the outcome variable: Base model: $R^2 = .00, F(1, 86) = .19, p = .68$. Full model: $R^2 = .03, F(3, 84) = .91, p = .44$. $\Delta R^2 = .03, F(2, 84) = 1.34, p = .27$

strategies (Bakar, et al., 2011; Mangeot et al., 2002; McAuley et al., 2010; Vriezen and Pigott, 2002).

Impulsivity and Anxiety Link to Global and Local RC

The hypothesis that high impulsivity would be associated with better global skills and high anxiety would be associated with better local skills, was partially supported. The results showed that adding personality trait impulsivity to the regression model, along with general EFs as an independent variable, increased the explained variance in global RC performance. Specifically, while difficulties in general EFs predicted reduced global RC performance, high impulsivity increased global RC performance, suggesting that in non-clinical populations the consequences of impulsivity are not negative in certain tasks. In this regard, Dickman (1993) posits that impulsivity is composed of two subconstructs: dysfunctional and functional impulsivity. Dysfunctional impulsivity refers to speedy and unreflective decision making, similar to most definitions of impulsivity that connote maladaptively. In contrast, functional impulsivity refers to fast information processing that is beneficial and even an optimal cognitive style (Dickman, 1993; Dickman, 2000); these aspects of impulsivity include the tendency to make quick decisions and react without going “into the details,” which may help with quick, successful task completion. Indeed, global RC questions solicit ‘bottom-line’ gist representations without need for detailed analysis.

To the best of our knowledge, there are no studies that have examined the relationship between functional impulsivity and

RC. Thus, further research is needed to clarify the impulsivity-RC relationship, taking into consideration functional impulsivity, and to account for possible interference of impulsivity in learning processes. This may help us understand whether impulsivity is directly related to RC skills or acts as a moderator between individuals’ resources and achievements.

As for anxiety, it was not found to be associated with global or local RC. This does not corroborate with previous research on the distinct effects of anxiety on language-related cognitive functions, including learning processes (Fales et al., 2008; Basten et al., 2012; Vytal et al., 2012; Visu-Petra et al., 2013). The non-significant effect of anxiety on RC subskills may be explained by the notion that there is less vulnerability to disturbances from worrying thoughts during high-cognitive load tasks that occupy executive resources. Alternatively, more effort may be allocated to high-load tasks at the expense of processing efficiency (related to longer reaction times) but not at the expense of accurate performance (related to intact accuracy) (Eysenck and Calvo, 1992; Eysenck et al., 2007). This is supported by the dual-pathway compensatory effort idea of Eysenck and colleagues’ (2007, 2011) attentional control theory (ACT), according to which anxious individuals often perform just as well as their non-anxious peers. Although worries are distracting and make processing less efficient, they may also motivate anxious individuals to employ compensatory efforts to overcome negative effects of anxiety, resulting in enhanced performance comparable to their non-anxious peers (Ansari and Derakshan, 2010; Basten et al., 2012). Indeed, highly anxious individuals may expend compensatory effort on task processing (in this case, RC) to make up for poorer attentional control.

TABLE 3 | Hierarchical regression model with global reading comprehension and local reading comprehension as the outcome variables and cognitive flexibility, impulsivity, and anxiety as independent variables.**Model 3: Outcome variable: Global reading comprehension**

Base model					Full model			
$R^2 = .03, F(1, 88) = 2.95, p = .09$					$R^2 = .03, F(3, 86) = .99, p = .40$			
					$\Delta R^2 = .001, F(2, 86) = .05, p = .95$			
Variable	b(se)	B	P	95%CI	b(se)	β	P	95%CI
WCST Lg10(PE)	-0.06 (0.03)	-0.18	0.09	[-0.12, 0.01]	-0.05 (0.03)	-0.18	0.10	[-0.13, 0.02]
BIS-11					0.00 (0.00)	0.02	0.83	[-0.002, 0.002]
STAI-TA					0.00 (0.00)	-0.03	0.79	[-0.002, 0.001]
Constant	0.99 (0.04)		<0.001	[0.92, 1.06]	0.99 (0.07)		<0.001	[0.86, 1.11]

Model 4: Outcome variable: Local reading comprehension

Base model					Full model			
$R^2 = .06, F(1, 88) = 5.45, p = .02$					$R^2 = .08, F(3, 86) = 2.33, p = .08$			
					$\Delta R^2 = .02, F(2, 86) = .78, p = .46$			
Variable	b(se)	B	P	95%CI	b(se)	β	P	95%CI
WCST Lg10(PE)	-0.08 (0.03)	-0.24	0.02	[-0.14, -0.01]	-0.08 (0.03)	-0.26	0.02	[-0.17, -0.002]
BIS-11					0.00 (0.001)	-0.00	0.99	[-0.002, 0.002]
STAI-TA					0.001 (0.001)	0.13	0.23	[-0.001, 0.003]
Constant	0.99 (0.04)		<0.001	[0.92, 1.06]	0.96 (0.07)		<0.001	[0.83, 1.08]

Notes: WCST, Lg10(PE), The Wisconsin Card Sorting Task log transformation of the number of perseverative errors; BIS-11, Barratt Impulsiveness Scale; STAI-TA, State-Trait Anxiety Inventory—Trait Anxiety.

In sum, the connections between EFs and impulsivity/anxiety traits, and the way they affect RC subskills, appears to depend on the cognitive demands of the task at hand. In particular, global and local reading comprehension subskills appear to engage different aspects of the cognitive domain of RC; they, in turn, are associated differently with general EFs, cognitive flexibility, and personality traits. This distinction may provide an important contribution to theoretical interdisciplinary and applied educational research.

Limitations

There are a few limitations need to be considered for future study. As a preliminary evaluation of the effects of EFs and personality traits (impulsivity and anxiety) on global and local RC, the current work has some limitations. It would be valuable to examine general EFs and specific aspects of EFs (e.g., working memory) at a fine-grain functional level using additional performance-based tasks as well as using behavioral questionnaires with ecological validity that provide important information on the role of EFs in daily life functioning. Incorporating multivariate indices for EFs will enable more complex models about possible relationships between EFs and RC. The same holds for multifaceted personality traits as impulsivity and anxiety, in which a multi-method approach that incorporates both performance-based tests and self-reports should be considered in future studies. Also, the sample consisted of undergraduate students enrolled in psychology and education courses, which resulted in a predominantly educated female sample. This limits the extent to which generalizations can be made. Thus, it would be beneficial to confirm and extend these conclusions by a more diverse

sample (e.g., education level and sex). Clinical samples with different disorders should also be examined as they could assist in understanding the impact of the traits more than typically developing individuals. Finally, it is important to note that idiom specificity and generalizations should be cautioned the current data concerns the Hebrew language while most studies refer to English speaking samples.

CONCLUSION

The findings suggest distinct roles of general EFs, cognitive flexibility, and trait impulsivity on global and local RC subskills. Information about university students' global and local information processing styles/levels may be useful for pedagogical staff to take into consideration in order to tailor instruction methodologies. Further, the evidence from the current study suggests that impulsive individuals may be less prone to RC difficulties when global information is required; this finding may be quite important when building educational programs and identifying teaching methodologies better suited to students exhibiting impulsive behavior. Indeed, both global and local information strategies could be particularly useful for tailoring instruction to specific students while simultaneously introducing complementary strategies that provide scaffolding for enhanced RC skills Anderson, 2002, Blair and Diamond, 2008, Carlson and Meltzoff, 2008, Eysenck and Derakshan, 2011, Kieffer et al., 2013, Murdock et al., 2013, Nitschke et al., 2000, Pham, 2016, Riggs et al., 2014, Roth et al., 2014, Rozencwajg and Corroyer, 2005, Sadeh and Bredemeier, 2011, Salthouse et al., 2003,

Sweitzer et al., 2008, Ursache and Raver, 2014, Zelazo and Müller, 2002.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The studies involving human participants

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were reviewed and approved by authors' Bar-Ilan university IRB. The participants provided their written informed consent to participate in this study. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

The manuscript was written by RL and CA. Research design was conducted by RL and CA. Data was collected and analyzed by RL and CA. RL was the corresponding author for the paper. All authors contributed to the article and approved the submitted version.

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