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Establishing the Attention-Distractibility Trait

Sophie Forster[1] and Nilli Lavie[2]
[1]School of Psychology, University of Sussex, and [2]Institute of Cognitive Neuroscience, University College London

Abstract
Failures to focus attention will affect any task engagement (e.g., at work, in the classroom, when driving). At the clinical end, distractibility is a diagnostic criterion of attention-deficit/hyperactivity disorder (ADHD). In this study, we examined whether the inability to maintain attentional focus varies in the overall population in the form of an attention-distractibility trait. To test this idea, we administered an ADHD diagnostic tool to a sample of healthy participants and assessed the relationship between ADHD symptoms and task distraction. ADHD symptom summary scores were significantly positively associated with distractor interference in letter-search and name-classification tasks (as measured by reaction time), as long as the distractors were irrelevant (cartoon images) rather than relevant (i.e., compatible or incompatible with target names). Higher perceptual load during a task eliminated distraction irrespective of ADHD score. These findings suggest the existence of an attention-distractibility trait that confers vulnerability to irrelevant distraction, which can be remedied by increasing the level of perceptual load during the task.

Keywords
attention, distraction, ADHD, perceptual load, personality traits

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Focused attention is vital for all information processing, from the earliest stages of visual perception (including information that remains subliminal, e.g., Bahrami, Carmel, Walsh, Rees, & Lavie, 2008) through encoding into memory (e.g., Jenkins, Lavie, & Driver, 2005) and control over response selection (e.g., Lavie, Hirst, De Fockert, & Viding, 2004). It comes as no surprise then that the inability to focus attention in the face of irrelevant distractions can lead to detrimental effects on task performance and behavior. Indeed, individual-difference studies have established that people who report greater frequency of attention failures are at increased risk of various accidents and task failures, ranging from reduced efficiency in the workplace (Wallace & Vodanovich, 2003) and potentially costly errors (e.g., failing to save work while computing; Jones & Martin, 2003), to serious accidents (e.g., car accidents or serious falls; Arthur & Doverspike, 1992; Larson, Alderton, Neideffer, & Underhill, 1997; Larson & Merritt, 1991).

The most extreme manifestations of inattention are seen in the clinical syndrome of attention-deficit/hyperactivity disorder (ADHD), a neurodevelopmental psychiatric disorder involving two major symptom categories: inattentive and hyperactive-impulsive behaviors. Indeed, being "easily distracted by extraneous stimuli" (*Diagnostic and Statistical Manual of Mental Disorders*, 5th ed.; American Psychiatric Association, 2013, p. 59) is a clinical diagnostic symptom for ADHD, and symptoms in the inattentive category persist into adulthood more commonly than do symptoms in the hyperactive-impulsive category (Wilens, Faraone, & Biederman, 2004).

Taken together, findings of various levels of attention failures in the nonclinical population and the observations of heightened levels of distraction in ADHD led us to hypothesize that there is an underlying attention-distractibility trait. Such a trait would confer vulnerability to distraction across the general population and manifests itself as ADHD at the clinical end of the spectrum.

In the present research, we sought to establish and index the putative attention-distractibility trait by assessing whether the degree of ADHD symptoms in a large

Corresponding Author:
Sophie Forster, School of Psychology, University of Sussex, Falmer BN1 9QH, United Kingdom
E-mail: s.forster@sussex.ac.uk

nonclinical sample was correlated with the level of irrelevant distraction in an attention task. Because ADHD diagnosis is typically made during childhood, and adult diagnosis requires symptoms to have been present since childhood, we asked our participants to report the extent to which they had experienced symptoms of ADHD during childhood, using the Childhood Symptoms Scale—Self-Report Form (Barkley & Murphy, 1998). We then examined whether these symptoms correlated with the magnitude of distraction that participants exhibited on search and classification tasks with irrelevant distractors, using the irrelevant-distractor paradigm (Forster & Lavie, 2008a, 2008b).

The irrelevant-distractor paradigm is designed to measure distraction by stimuli that are entirely irrelevant to the task at hand, thereby capturing the type of irrelevant distractions that appear to reflect a true attention failure (e.g., being distracted by noticing an interesting-looking passerby while trying to read some work-related material). The irrelevant-distractor paradigm assesses the letter-search performance costs (i.e., the slowing of reaction time, or RT) when colorful cartoon images entirely irrelevant to the letter-search task in visual appearance, meaning, and location are presented in the periphery. Given the irrelevance of the distractors to the task, interference does not depend on the specific nature of the attention task and has indeed been found across several such tasks (Forster & Lavie, 2008a, 2008b, 2011, 2014). The irrelevant-distractor paradigm thus provides a fairly robust index of distractibility and reflects a fundamental failure of focused attention.

Moreover, other measures of distraction using response-competition tasks have not always shown increased distractor interference in ADHD (e.g., Albrecht et al., 2008; Booth, Carlson, & Tucker, 2007; Brodeur & Pond, 2001; Chan et al., 2009; Chang, Davie, & Gavin, 2009; Geurts, Van Meel, & Luman, 2008; Herrmann et al., 2010; Huang-Pollock, Nigg, & Carr, 2005; Lundervold et al., 2011; McLoughlin et al., 2009; Wild-Wall, Oades, Schmidt-Wessels, Christiansen, & Falkenstein, 2009), whereas a recent study using the irrelevant-distractor paradigm revealed strikingly increased distractor interference in adults diagnosed with ADHD compared with age-matched control participants (Forster, Robertson, Jennings, Asherson, & Lavie, 2014). Thus, we anticipated that the irrelevant-distractor paradigm would be a more sensitive measure of the attention-distractibility trait than a response-competition task.

In addition to attempting to establish a measure of the attention-distractibility trait, we examined whether this trait involves reduced ability to improve attentional focus in conditions of high perceptual load. The level of perceptual load in the task is a well-established, powerful determinant of distractor processing (e.g., Lavie, 1995, 2005). High perceptual load in the task reduces or even eliminates distraction because attentional resources are more fully engaged in processing the relevant task stimuli. Would individuals prone to attention deficits also fail to engage more resources in tasks of higher perceptual load? Or would perceptual load be an effective remedy for all people alike (e.g., Forster & Lavie, 2007; Forster et al., 2014)?

Experiment 1

The experiment was approved by the University College London research ethics committee and was carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki.

Method

To investigate these questions, we asked a sample of healthy participants to perform a visual search task involving either low perceptual load (i.e., target and nontarget letters are dissimilar) or high perceptual load (target and nontarget letters are similar) while ignoring any irrelevant distractors. On 25% of the trials, an irrelevant colorful cartoon image appeared outside the search array. Irrelevant distraction was measured by RT interference (i.e., the extent to which RT was longer in the presence compared with the absence of this distractor). The magnitude of childhood ADHD symptoms was assessed by administering the ADHD Childhood Symptoms Scale—Self-Report Form (Barkley & Murphy, 1998).

Participants. We approached an entire class of around 100 students for participation; this number is in keeping with typical sample sizes in this field. All willing participants (93 of the 100 approached; 12 men; mean age = 20 years, $SD = 3.03$, range = 18–39 years) were tested before data analysis commenced. We excluded from analysis the results of 16 participants (1 man), either because their RT was more than 2 standard deviations greater than the mean or because their accuracy was at chance level (< 55%) in the high-load condition.[1] None of the participants reported a prior diagnosis of ADHD.

Stimuli and procedure. All stimuli were created and presented using E-Prime software (Version 1.1; Schneider, Eschman, & Zuccolotto, 2002) on IBM-compatible personal computers with 15-in. monitors. A viewing distance of approximately 57 cm was maintained using a string attached to the head of the participant with masking tape. Each trial of the task commenced with a 500-ms fixation, followed immediately by the stimulus display (100 ms; see Fig. 1a). This consisted of a search set of six letters arranged in a circular formation (radius subtending 1.6° of

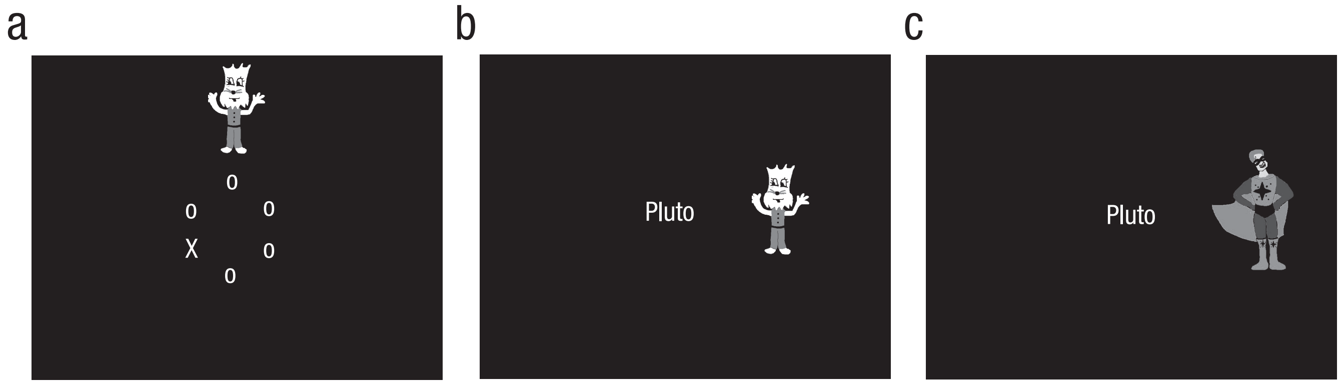

Fig. 1. Stimulus display for the distractor tasks in Experiment 1 and Experiment 2. In Experiment 1 (a), participants searched for a target letter (in the example here, an *X*) in a circle of letters. On 25% of the trials, an irrelevant distractor cartoon appeared either above or below the circle (as illustrated here). In the high-load condition, the nontarget letters were uppercase angular letters; in the low-load condition, illustrated here, the nontarget letters were lowercase *o*s. In Experiment 2, participants classified a name in the center of the display as being that of either a superhero or a Disney character. On 20% of the trials, a distractor cartoon appeared to the left or right of the name. On a third of these trials, the distractor was irrelevant; that is, it was neither a superhero nor a Disney character (b). Two thirds of the distractor trials had a response-competition distractor, a cartoon character that was either in the same category as the named character (compatible) or a cartoon character that was in the opposite category (incompatible), as shown here (c). Note that these illustrations are not the actual displays used because the characters used are copyrighted.

visual angle). One of the six letters was a target letter (subtending 0.6° × 0.4°), either an *X* or an *N*. Participants were asked to respond as quickly as possible while being accurate, using the numerical keypad to press the "0" key if the target was an *X* and the "2" key if the target was an *N*. In the low-load condition, the five nontarget letters were lower-case *o*s (subtending 0.15° × 0.12°); in the high-load condition, the nontarget letters were heterogeneous angular letters of the same dimensions as the target, selected at random from the set *K, V, W, Z, M*, and *H*. All letter stimuli were presented in gray on a black background. A tone sounded if an incorrect response was made or if no response was made within a 2,000-ms time window.

On 75% of trials, the search set appeared alone: This was the no-distractor baseline condition. On the remaining 25% of trials, an entirely task-irrelevant distractor was presented either above or below the target search set, at 4.6° from fixation and a minimum of 0.6°, edge-to-edge, from the nearest letter stimulus. The distractor was a full-color image of one of six possible cartoon characters: Superman, Spider-Man, Pikachu, SpongeBob SquarePants, Mickey Mouse, and Donald Duck. The distractor subtended 2.8° to 4° vertically by 2.8° to 3.2° horizontally. The distractors remained on-screen until a response was made. Target identity, target position, distractor position, load condition, and their combinations were fully counterbalanced across blocks.

Participants first completed 6 practice trials (3 for each load condition) in which all stimuli remained on screen until response, followed by 24 practice trials (12 for each load condition) with the same durations used in the main experimental trials. Participants who failed to achieve an overall accuracy level of at least 65% were given further instructions and repeated the practice trials. Participants then completed eight 48-trial blocks of the main task; load condition was manipulated between blocks in the order ABBAABBA or BAABBAAB (counterbalanced between participants). The first three trials in each block, which were always no-distractor trials, were intended as warm-up trials and were therefore excluded from analysis.

Finally, participants used the Childhood Symptoms Scale—Self-Report Form (Barkley & Murphy, 1998), administered via computer, to rate the extent to which they had experienced symptoms of ADHD during childhood. Participants rated 18 items concerning how often they had experienced symptoms of ADHD between the ages of 5 and 12. They used a Likert-type scale ranging from 0 (*never or rarely*) to 3 (*very often*). Each of the 18 items is based closely on one of the 18 diagnostic criteria for ADHD from the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; American Psychiatric Association, 2000); 9 of the items correspond to the inattentive subtype, and 9 of the items correspond to the hyperactive-impulsive subtype.

Barkley and Murphy (1998) suggested two methods for calculating scores: summary scores, which are the sum of each response (i.e., adding 1 to the score for every response of "1," adding 3 for every response of "3," etc.), and symptom count, which involves counting the number of items with a response of "2" or "3." Summary scores were used in the present study to index childhood ADHD symptoms because they provide a more continuous measure and have greater sensitivity to capture subclinical variation in symptoms (i.e., reports of "1" vs. "0") than do symptom counts.

Results

Only correct responses were included in the RT analysis, which is standard practice when using the irrelevant-distractor paradigm. RTs under 100 ms were presumed to be anticipatory and were therefore excluded from all analyses. To reduce noise in the data, we also excluded all RTs over 1,500 ms (< 0.5% of all responses across participants) from analyses. Mean RTs and error rates for each load and distractor condition appear in Table 1.

Overall group RT. Mean RTs were entered into a 2 × 2 repeated measures analysis of variance (ANOVA) with factors of load condition (low, high) and distractor condition (present, absent). This ANOVA revealed a significant main effect of distractor condition; performance was slower in the presence of the distractor than in its absence, $F(1, 76) = 9.82$, $MSE = 637.73$, $p = .002$, $\eta_p^2 = .114$. In addition, a main effect of load condition, $F(1, 76) = 283.00$, $MSE = 9{,}998.94$, $p < .001$, $\eta_p^2 = .788$, confirmed that the manipulation of load was effective. As expected, there was a significant interaction between load condition and distractor condition, $F(1, 76) = 42.18$, $MSE = 457.27$, $p < .001$, $\eta_p^2 = .357$, reflecting a reduction in the level of distractor interference under high load compared with low load. These results demonstrate that irrelevant distractors significantly interfered with task performance in conditions of low perceptual load only. Conditions of high perceptual load led to significant reduction in distractor interference, in line with previous findings (Forster & Lavie, 2008a; Forster et al., 2014).

We note that the reduction in distractor interference in the high-load condition cannot be accounted for by suggesting that the search nontarget letters produced their own distraction effect that undermined distraction by the irrelevant yet salient cartoon character. If this were the case, we would expect a positive correlation between the effect of load on RT in the no-distractor condition (reflecting the strength of putative distraction by the neutral search letters) and distractor interference in the low-load condition, because both would be mediated by the same distraction mechanism. However, there was no such correlation; in fact, the trend was in the opposite direction, $r = -.133$, $p = .250$. This result is in line with the many previous findings of distractor effects being reduced by conditions of high perceptual load that involve no increase in the relevant task-set size (e.g., Lavie, 1995; Lavie, Lin, Zokaei, & Thoma, 2009; for reviews, see Lavie, 2005, 2010). These findings thus confirm the sensitivity of our distraction measure to index both irrelevant-distractor interference effects and their modulation by perceptual load.

Individual differences. Our main research question concerned the relationship between ADHD symptoms and the magnitude of distractor RT interference. Given

Table 1. Results From Experiment 1: Comparison of Mean Reaction Times and Error Rates in the Irrelevant-Distractor and No-Distractor Conditions

	Distractor condition		
Load condition and measure	Irrelevant distractor	No distractor	Difference
Low load			
RT	516 ms (6)	491 ms (6)	25 ms
Error rate	14%	13%	
High load			
RT	692 ms (13)	699 ms (14)	–7 ms
Error rate	29%	26%	

Note: RT = reaction time. The values in parentheses are standard errors. Difference was calculated as irrelevant distractor minus no distractor.

that high perceptual load eliminated distractor interference (see Table 1), we used RT interference in the low-load condition as the distraction index in our individual differences analyses. To normalize distractor interference across individual variations in overall RTs, we calculated the percentage increase in the mean RT due to distraction by subtracting RT in the distractor-absent condition from RT in the distractor-present condition and then dividing the result by the RT in the distractor-absent condition. Average distractor interference was 5% (range = −3%–19%). ADHD scores ranged between 1 and 38 (M = 13); the mean score for symptoms relating to the inattention subtype was 6 (range = 0–20), and that for the hyperactive-impulsive subtype was 7 (range = 0–27). As our hypothesis regarding an attention-distractibility trait predicts, there was a significant correlation between childhood symptoms of ADHD and the magnitude of distractor interference in the low-load condition, $r(75) = .323$, $p = .004$ (Fig. 2a). Note that this correlation was found across the full range of scores, which suggests a continuous trait rather than simply inflated distraction among those participants with a very high ADHD score.

Note that the correlation remained significant after we excluded the only 3 participants with a score that appeared to be in the clinical range for this scale (> 34.4; e.g., Barkley & Murphy, 1998), $r(72) = .355$, $p = .002$. Examination of the scores for each ADHD subtype revealed the same pattern of results that was found for the overall ADHD scores. Scores on both subtypes correlated positively with distractor interference—inattention subtype: $r(75) = .319$, $p = .005$; hyperactive-impulsive subtype: $r(75) = .268$, $p = .019$.

We next examined whether the effect of perceptual load on distraction was moderated by the ADHD scores. The magnitude of the effects of load on distraction was calculated for each participant (i.e., by subtracting distractor interference in high-load condition from that in

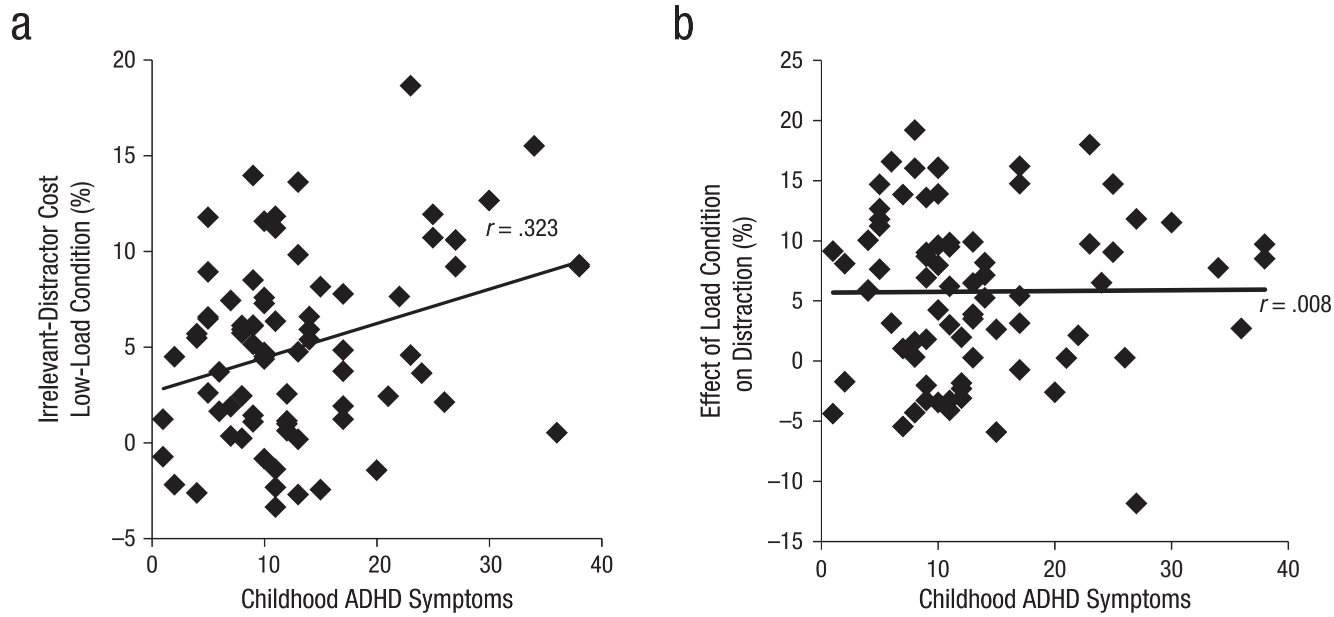

Fig. 2. Results from Experiment 1. Scatterplot (with best-fitting regression line) showing (a) irrelevant-distractor interference for the low-load condition and (b) the effect of load on distraction as a function of attention-deficit/hyperactivity disorder (ADHD) symptoms during childhood. ADHD symptoms are measured using the total summary score on Barkley and Murphy's (1998) Childhood Symptoms Scale—Self-Report Form. The effect of load on distraction was calculated by subtracting distractor interference in the high-load condition from distractor interference in the low-load condition.

the low-load condition), and the correlation with ADHD scores was computed. This analysis revealed no correlation between effect of load on distraction and ADHD score, $r = .008$, $p > .250$. This finding indicates that high load was equally effective in reducing distractor interference regardless of participants' ADHD scores (see Fig. 2b).[2]

Errors. The ANOVA on error rates revealed significant main effects of load condition, $F(1, 76) = 185.02$, $MSE = 79.39$, $p < .001$, $\eta_p^2 = .709$, and distractor condition, $F(1, 76) = 12.17$, $MSE = 29.93$, $p = .001$, $\eta_p^2 = .138$, on error rates in the overall group. These effects mirrored the pattern of results found for the RT measure: There were more errors in the high-load condition (than in the low-load condition) and in the presence of a distractor (than in the absence of a distractor). The Load Condition × Distractor Condition interaction had no significant effect on error rates, $F(1, 76) = 1.61$, $MSE = 21.40$, $p = .208$, $\eta_p^2 = .021$. Childhood ADHD symptoms did not correlate significantly with the magnitude of the effect of distractor condition or load condition on error rate (both *p*s > .250).

Experiment 2

The results of Experiment 1 established our irrelevant-distractor paradigm as a sensitive index of individual differences in the likelihood of attentional failures, as measured across the general population with the ADHD diagnostic tool. We propose that our irrelevant-distractor paradigm is more sensitive than previous distraction measures for capturing the attention-distractibility trait because it measures failures to ignore distractors despite their utter irrelevance to the task. In contrast, the popular response-competition-distractor measures assess interference from distractor items that are associated with target responses (and are either compatible or incompatible with the correct target response on a given trial). Thus, the distractors are task related. Failures to ignore items that are task-related may reflect a more subtle attention deficit than that measured with ADHD diagnostic tools. Task relevance may thus be the key factor for a sensitive measure of the attention-distractibility trait.

However, apart from their task irrelevance, the cartoon images we presented were highly salient in terms of visual appearance (e.g., they were colorful complex images), familiarity, meaning, and infrequent presentation (in itself known to enhance attention capture; Forster & Lavie, 2008a). None of these features is characteristic of the distractors typically presented in response-competition tasks. Such distractors do not tend to be visually complex (e.g., letters or arrows) or salient, and they appear on every trial.

To examine our proposal that task irrelevance is the key factor in measuring the attention-distractibility trait, we used irrelevant distractors and response-competition distractors that were matched in their salience, familiarity, meaning, and frequency in Experiment 2. Thus, participants performed a speeded name-classification task in which we presented cartoon images infrequently (20% of trials). The cartoon characters were presented either as response-competition distractors (i.e., the cartoon character's name was compatible or incompatible with the target name) or response-irrelevant distractors (i.e., the cartoon character was unrelated to the target name categories; see Fig. 1). Because all factors of the distractors were equal except response relevance, we could determine whether this is the critical factor for measuring the attention-distractibility trait.

Method

The experiment was approved by the University College London research ethics committee and was carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki.

Participants. One hundred one undergraduate students at University College London (81 women; mean age = 18.94 years, *SD* = 0.92, range = 18–22) participated in Experiment 2. Participants were recruited in the same manner as in Experiment 1 but from a different class. Four of the participants reported having been previously diagnosed with ADHD but were not taking any ADHD medication at the time of testing. The data of 5 participants were excluded from the analysis, either because their RT was more than 2 standard deviations greater than the mean or because their accuracy was at chance level (< 55%) in at least one of the experimental conditions. A further 22 participants were excluded because in the posttest, they reported having not recognized more than one cartoon distractor image (see note 2).

Stimuli and procedure. All stimuli and procedures were similar to those in Experiment 1, with the following exceptions. The high-load condition was not included. Each task display consisted of 1 of 12 possible target names, presented in gray letters on a black background. The target name was equally likely to be selected from six superheroes ("Superman," "Spiderman," "Batman," "Robin," "Hulk," "Wolverine") and six Disney characters ("Mickey," "Donald," "Pluto," "Pooh," "Tigger," "Piglet"). The target name subtended 0.5° vertically by 0.9° to 2.3° horizontally, and it was presented in one of six locations with equal likelihood: 0.3°, 1.3°, or 2.3° of visual angle above or below fixation. Participants were asked to classify the name as referring to a superhero (by pressing the "0" key) or to a Disney character (by pressing the "2" key). Cartoon distractor images (subtending 3.8°–5° × 2.4°–3.8°) were presented either to the left or to the right of the target name (4.4° from fixation; the distance from the nearest edge to the edge of the target name was at least 0.7°). These distractors were equally likely to be irrelevant to the target response (e.g., an image of a cartoon character that was neither a superhero nor a Disney character might appear with the name of the Disney character "Pluto"; see Fig. 1b), compatible with the target response (e.g., an image of Pluto with the name "Pluto"), or incompatible with the target response (e.g., an image of a superhero with the name "Pluto"; see Fig. 1c) with the target response.

Each block consisted of 60 trials—48 without a distractor and 12 with a distractor (4 from each distractor category). All stimuli remained on-screen until either a response was made or 2,000 ms passed. A 90-ms beep sounded on incorrect or missed responses. Participants first completed at least 72 practice trials with no distractors; these trials were repeated until 65% accuracy was reached, and then participants completed six blocks of the main experiment. Finally, the distinction between irrelevant distractors and response-competition distractors depended on the ability of participants to recognize and correctly classify the characters. Consequently, after completion of the ADHD questionnaire, participants were presented with each of the distractor images used in the experiment. They were asked to confirm whether they had been familiar with the character before the experimental session and to classify the image as a superhero, Disney character, or other cartoon character (neither superhero nor Disney). This was followed by a computerized question asking participants to report by button press whether they had ever been diagnosed with ADHD and, if so, whether they were currently taking any medication to treat ADHD.

Results

Mean overall classification accuracy in the posttest was 99% (Table 2). Mean RTs for correct responses and error rates were entered into two repeated measures ANOVAs with the factor of distractor condition (incompatible distractor, compatible distractor, irrelevant distractor, no distractor).

RTs. We found a significant main effect of distractor condition, $F(3, 219) = 199.71$, $MSE = 1{,}545.06$, $p < .001$, $\eta_p^2 = .732$. Planned comparisons revealed that, as in previous studies (e.g., Forster & Lavie, 2007, 2008a, 2008b), there was significant distractor interference both in the irrelevant-distractor condition (RT was slower than in the no-distractor condition), $t(73) = 17.71$, $SEM = 6.33$, $p < .001$, and in the incompatible-distractor condition (RT was slower than in the compatible-distractor condition), $t(73)$

Table 2. Results From Experiment 2: Comparison of Mean Response Times and Error Rates in the Four Distractor Conditions

	Comparison of the incompatible- and compatible-distractor conditions			Comparison of the irrelevant- and no-distractor conditions		
Measure	Incompatible distractor	Compatible distractor	Difference	Irrelevant distractor	No distractor	Difference
RT	752 ms (12)	645 ms (9)	107 ms	733 ms (11)	622 ms (8)	112 ms
Error rate	20%	6%		11%	9%	

Note: RT = reaction time. The values in parentheses are standard errors. Differences were calculated as incompatible distractor minus compatible distractor and irrelevant distractor minus no distractor.

= 14.78, SEM = 7.26, p < .001. Note that the overall mean level of interference associated with response-competition effects (i.e., incompatible vs. compatible distractors) did not differ from the cost associated with irrelevant-distractor effects (i.e., presence vs. absence), t < 1, which is similar to the findings of Forster and Lavie (2008b). Thus, any divergence in the extent to which these measures relate to ADHD symptoms cannot be attributed to differences in the interference potency of the two distractor types.

Individual differences. RT interference for irrelevant distractors ranged from 0.5% to 41% (M = 18%) of the task RT. ADHD scores ranged between 3 and 39 (M = 13.48); the mean score for inattentive symptoms was 6, and the mean score for hyperactive-impulsive symptoms was 7. As in Experiment 1, ADHD score was positively correlated with the magnitude of irrelevant-distractor interference, $r(72)$ = .323, p = .005, two-tailed (see Fig. 3). As in the previous experiment, this correlation was found for both symptoms of inattention, $r(72)$ = .242, p = .038, and symptoms of hyperactivity and impulsivity, $r(72)$ = .329, p = .004.

Response-competition interference (calculated as the percentage increase in RT in the incompatible-distractor condition compared with the compatible-distractor condition) ranged from −4% to 49% (M = 16%). In contrast to the pattern found with irrelevant-distractor interference, there was no correlation between ADHD score and the magnitude of response-competition interference, $r(72)$ = .034, p > .250, two-tailed.

Errors. Across participants, the error data showed the same pattern as the RT effects: There was a main effect of distractor condition, $F(3, 219)$ = 89.54, p < .001, η_p^2 = 551. This effect reflected a greater error rate in the irrelevant-distractor condition compared with the no-distractor condition, $t(73)$ = 2.17, SEM = 0.76, p = .03, and a greater error rate in the incompatible-distractor condition than in the compatible-distractor condition, $t(73)$ = 13.29, SEM = 1.03, p < .01. As in Experiment 1, there were no significant correlations between error rate and any of the ADHD symptoms (all ps > .250).

General Discussion

The present findings establish an attention-distractibility trait that confers vulnerability to irrelevant distraction across the general population. The results also suggest that the magnitude of individual distractor interference in our irrelevant-distractor paradigm could be used to

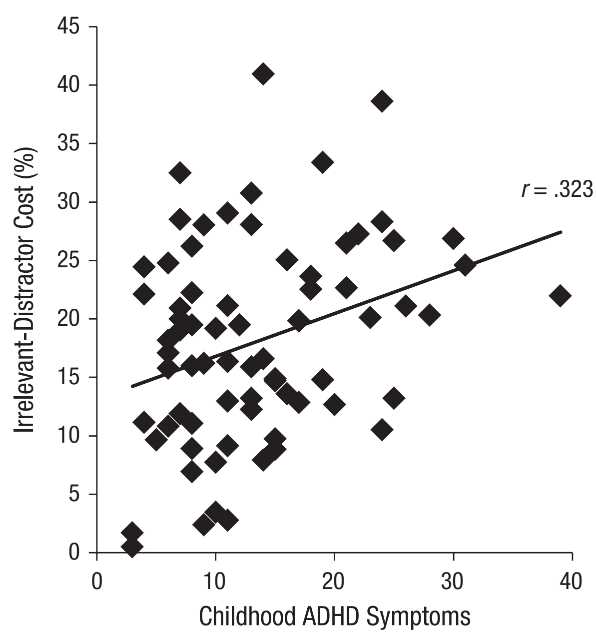

Fig. 3. Results from Experiment 2. Scatterplot (with best-fitting regression line) showing the association between irrelevant-distractor interference and the number of attention-deficit/hyperactivity disorder (ADHD) symptoms during childhood. ADHD symptoms are indexed using the total summary score on Barkley and Murphy's (1998) Childhood Symptoms Scale—Self-Report Form. Irrelevant-distractor interference was calculated as the percentage increase in RT in the irrelevant-distractor-present condition compared with the no-distractor condition.

measure this trait. In two experiments involving a total of 194 participants, we demonstrated that the level of interference on task responses produced by entirely irrelevant distractors was significantly correlated with the level of reported ADHD symptoms. These correlations reflected a trait-like continuum of variation across our sample, rather than being driven by the effects of high-scoring participants. In addition, both symptoms of inattention and symptoms of hyperactivity and impulsivity were significantly correlated with the magnitude of interference produced by irrelevant distractors. This finding is consistent with the view that the full set of ADHD symptoms forms a cohesive trait. Our findings thus appear to reflect this trait and do not seem to be attributable simply to the items that specifically mention distraction. Overall the results suggest an attention-distractibility trait in the general population.

Our findings also clarify that the presentation of distractors that are entirely irrelevant to the task is a critical factor for producing a sensitive measure of the attention-distractibility trait. This is demonstrated by the fact that ADHD score was associated with the magnitude of RT interference by irrelevant distractors but was not associated with task-related distraction in the form of response-competition effects. This dissociation was observed even though the response-competition distractors were meaningful and salient cartoon characters, similar to those used for irrelevant distractors.

Attention serves as the gateway to all information processing; therefore, attention failures are known to have a profound and wide-ranging impact on many mental functions (from perception to response selection and memory) and their underlying neural recruitment. Thus, establishing a high level of the attention-distractibility trait is critical for determining how efficiently individuals can use their neural and cognitive resources. Individuals who score high on measures of the attention-distractibility trait are therefore likely to not make the best use of such resources, which will affect their performance in a variety of tasks. For example, students may fail to learn material from a lecture not because of any memory deficit, but rather because they did not pay sufficient attention to allow encoding into memory.

Recognizing and being able to measure the attention-distractibility trait may be an important step toward understanding why some individuals are more vulnerable than others to inattentive accidents and failures. In our tasks, distraction led to slowing of performance speed by up to 19% (Experiment 1) and 41% (Experiment 2) for the most distractible participants. Such costs are likely to produce significant impairments in performing daily-life tasks and activities. Indeed, at the clinical end, ADHD has been associated with increased risk of accidents and failures in school, at work, and in daily life (e.g., a greater likelihood of car accidents; Faraone et al., 2000). Similarly, longitudinal studies have also found that higher parental and teacher ratings of ADHD symptoms predict greater likelihood of educational underachievement and greater likelihood of being involved in a traffic accident (Fergusson, Lynskey, & Horwood, 1997; Woodward, Fergusson, & Horwood, 2000). Our study suggests that the level of risk for these negative outcomes, rather than being limited to a distinct clinical population, varies across the general population depending on levels of the attention-distractibility trait. This trait may thus be a significant yet underrecognized determinant of general well-being.

A recent finding that our irrelevant-distractor paradigm can also be used to predict the propensity for mind wandering (Forster & Lavie, 2014) suggests that vulnerability to both internal and external forms of irrelevant distraction shares a common determinant. An interesting possibility is that this common determinant could be the attention-distractibility trait—predisposing individuals to increased distraction from both external and internal sources. Indeed, ADHD symptoms have also been found to correlate with increased reports of mind wandering (Franklin et al., 2014; Shaw & Giambra, 1993).

The finding that increased perceptual load in the task was equally effective in reducing interference from irrelevant distractors across all participants, irrespective of ADHD symptoms, has an encouraging implication: Individuals with high levels of the attention-distractibility trait may find some respite from distraction during tasks with high perceptual demands. Finally, although we have discussed the importance of recognizing the implications for those individuals who have high scores on measures of the attention-distractibility trait, it is also important to identify those individuals who have low scores and thus can focus attention effectively even in the face of salient yet irrelevant distractions. Future research addressing the potential differences in neural networks associated with the attention-distractibility trait, as well as any impact of the trait on a variety of cognitive measures, should prove important for further establishing this important trait.

Author Contributions

Both authors contributed to the study concept and design and drafted the manuscript. Data collection and analysis were performed by S. Forster, and N. Lavie contributed to data analysis. Both authors approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Notes

1. A similar patterns of results was found with these participants included; in particular, the correlation between ADHD score and distractor interference remained significant, $r(93) = .241$, $p = .02$.
2. The pattern and significance of our results did not change whether we included all participants in the analysis or excluded the participants who reported having been diagnosed with ADHD.

References

Albrecht, B., Brandeis, D., Uebel, H., Heinrich, H., Mueller, U. C., Hasselhorn, M., . . . Banaschewski, T. (2008). Action monitoring in boys with attention-deficit/hyperactivity disorder, their nonaffected siblings, and normal control subjects: Evidence for an endophenotype. *Biological Psychiatry*, *64*, 615–625.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Arthur, W., & Doverspike, D. (1992). Locus of control and auditory selective attention as predictors of driving accident involvement: A comparative longitudinal investigation. *Journal of Safety Research*, *23*, 73–80.

Bahrami, B., Carmel, D., Walsh, V., Rees, G., & Lavie, N. (2008). Unconscious orientation processing depends on perceptual load. *Journal of Vision*, *8*(3), Article 12. doi:10.1167/8.3.12

Barkley, R. A., & Murphy, K. R. (1998). *Attention deficit hyperactivity disorder: A clinical workbook* (2nd ed.). New York, NY: Guilford Press.

Booth, J. E., Carlson, C. L., & Tucker, D. M. (2007). Performance on a neurocognitive measure of alerting differentiates ADHD combined and inattentive subtypes: A preliminary report. *Archives of Clinical Neuropsychology*, *22*, 423–432.

Brodeur, D. A., & Pond, M. (2001). The development of selective attention in children with attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology*, *29*, 229–239.

Chan, E., Mattingley, J. B., Huang-Pollock, C., English, T., Hester, R., Vance, A., & Bellgrove, M. A. (2009). Abnormal spatial asymmetry of selective attention in ADHD. *Journal of Child Psychology and Psychiatry*, *50*, 1064–1072.

Chang, W. P., Davie, P. L., & Gavin, W. J. (2009). Error monitoring in college students with attention-deficit/hyperactivity disorder. *Journal of Psychophysiology*, *23*, 113–125.

Faraone, S. V., Biederman, J., Spencer, T., Wilens, T., Seidman, L. J., Mick, E., & Doyle, A. E. (2000). Attention deficit hyperactivity disorder in adults: An overview. *Biological Psychiatry*, *48*, 9–20.

Fergusson, D. M., Lynskey, M. T., & Horwood, L. J. (1997). Attentional difficulties in middle childhood and psychosocial outcomes in young adulthood. *Journal of Child Psychology and Psychiatry*, *38*, 633–644.

Forster, S., & Lavie, N. (2007). High perceptual load makes everybody equal: Eliminating individual differences in distractibility with load. *Psychological Science*, *18*, 377–381.

Forster, S., & Lavie, N. (2008a). Attentional capture by entirely irrelevant distractors. *Visual Cognition*, *16*, 200–214.

Forster, S., & Lavie, N. (2008b). Failures to ignore entirely irrelevant distractors: The role of load. *Journal of Experimental Psychology: Applied*, *14*, 73–83.

Forster, S., & Lavie, N. (2011). Entirely irrelevant distractors can capture and captivate attention. *Psychonomic Bulletin & Review*, *18*, 1064–1070.

Forster, S., & Lavie, N. (2014). Distracted by your mind? Individual differences in distractibility predict mind wandering. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*, 251.

Forster, S., Robertson, D. J., Jennings, A., Asherson, P., & Lavie, N. (2014). Plugging the attention deficit: Perceptual load counters increased distraction in ADHD. *Neuropsychology*, *28*, 91–97.

Franklin, M. S., Mrazek, M. D., Anderson, C. L., Johnston, C., Smallwood, J., Kingstone, A., & Schooler, J. W. (2014). Tracking distraction: The relationship between mind-wandering, meta-awareness, and ADHD symptomatology. *Journal of Attention Disorders*. Advance online publication. doi:10.1177/1087054714543494.

Geurts, H. M., Van Meel, C. S., & Luman, M. (2008). What's in a game: The effect of social motivation on interference control in boys with ADHD and autism spectrum disorders. *Journal of Child Psychology and Psychiatry*, *49*, 848–857.

Herrmann, M. J., Mader, K., Schreppel, T., Jacob, C., Heine, M., Boreatti-Hümmer, A., . . . Fallgatter, A. J. (2010). Neural correlates of performance monitoring in adult patients with attention deficit hyperactivity disorder (ADHD). *World Journal of Biological Psychiatry*, *11*, 457–464.

Huang-Pollock, C. L., Nigg, J. T., & Carr, T. H. (2005). Deficient attention is hard to find: Applying the perceptual load model of selective attention to attention deficit hyperactivity disorder subtypes. *Journal of Child Psychology and Psychiatry*, *46*, 1211–1218.

Jenkins, R., Lavie, N., & Driver, J. (2005). Recognition memory for distractor faces depends on attentional load at exposure. *Psychonomic Bulletin & Review*, *12*, 314–320.

Jones, G. V., & Martin, M. (2003). Individual differences in failing to save everyday computing work. *Applied Cognitive Psychology*, *17*, 861–868.

Larson, G. E., Alderton, D. L., Neideffer, M., & Underhill, E. (1997). Further evidence on dimensionality and correlates of the Cognitive Failures Questionnaire. *British Journal of Psychology*, *88*, 29–38.

Larson, G. E., & Merritt, C. R. (1991). Can accidents be predicted? An empirical test of the Cognitive Failures Questionnaire. *Applied Psychology*, *40*, 37–45.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human Perception and Performance*, *21*, 451–468.

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Sciences*, *9*, 75–82.

Lavie, N. (2010). Attention, distraction and cognitive control under load. *Current Directions in Psychological Science*, *19*, 143–148.

Lavie, N., Hirst, A., De Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General*, *133*, 339–354.

Lavie, N., Lin, Z., Zokaei, N., & Thoma, V. (2009). The role of perceptual load in object recognition. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 1346–1358.

Lundervold, A. J., Adolfsdottir, S., Halleland, H., Halmoy, A., Plessen, K. J., & Haavik, J. (2011). Attention Network Test in adults with ADHD: The impact of affective fluctuations. *Behavioral and Brain Functions*, *7*, Article 27. doi:10.1186/1744-9081-7-27

McLoughlin, G., Albrecht, B., Banaschewski, T., Rothenberger, A., Brandeis, D., Asherson, P., & Kuntsi, J. (2009). Performance monitoring is altered in adult ADHD: A familial event-related potential investigation. *Neuropsychologia*, *47*, 3134–3142.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime 2.0 user's guide*. Pittsburgh, PA: Psychology Software Tools.

Shaw, G. A., & Giambra, L. (1993). Task-unrelated thoughts of college students diagnosed as hyperactive in childhood. *Developmental Neuropsychology*, *9*, 17–30.

Wallace, J. C., & Vodanovich, S. J. (2003). Can accidents and industrial mishaps be predicted? Further investigation into the relationship between cognitive failure and reports of accidents. *Journal of Business and Psychology*, *17*, 503–514.

Wild-Wall, N., Oades, R. D., Schmidt-Wessels, M., Christiansen, H., & Falkenstein, M. (2009). Neural activity associated with executive functions in adolescents with attention-deficit/hyperactivity disorder (ADHD). *International Journal of Psychophysiology*, *74*, 19–27.

Wilens, T. E., Faraone, S. V., & Biederman, J. (2004). Attention-deficit/hyperactivity disorder in adults. *Journal of the American Medical Association*, *292*, 619–623.

Woodward, L. J., Fergusson, D. M., & Horwood, L. J. (2000). Driving outcomes of young people with attentional difficulties in adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*, 627–634.