# High perceptual load makes everybody equal: eliminating individual differences in distractibility with load

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Running head: Perceptual load and differences in distractibility

# High perceptual load makes everybody equal:

# Eliminating individual differences in distractibility with load

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Perceptual load has been found to be a powerful determinant of distractibility in laboratory tasks (Lavie, 2005). The present study assessed how perceptual load effects on distractibility in the laboratory relate to individual differences in the likelihood of distractibility in daily life. Sixty-one participants performed a response competition task in which perceptual load was varied. As expected, individuals reporting high (compared to low) levels of distractibility (on the "Cognitive Failures Questionnaire (CFQ): an established measure of distractibility in daily life) experienced greater distractor response-competition effects. Importantly, this relationship was confined to task-conditions of low perceptual load: high perceptual load reduced distractor interference for all participants, eliminating any individual differences. These findings suggest that the level of perceptual load in a task can predict whether individual differences in distractibility are found and that high load modifications of daily tasks may prove useful in preventing unwanted consequences of high distractibility.

High perceptual load makes everybody equal: Eliminating individual differences in distractibility with load

The ability to ignore irrelevant distracting stimuli is of great relevance for everyday life as the effects of distraction on behavior can have a range of consequences, some detrimental, (e.g. during driving) and some simply detracting from the quality of life (e.g. during reading). It is therefore important to examine how attention theories that prescribe determinants of focused attention and conversely distractibility relate to people's ability to ignore irrelevant distractors when focusing attention on relevant information in daily life.

The load theory of attention suggests that a major determinant of focused attention and the ability to ignore irrelevant distractors is the level of perceptual load in a current task (e.g. Lavie, 1995; Lavie, Hirst, De Fockert & Viding, 2004). Although irrelevant distractors interfere with tasks of low perceptual load (e.g. involving just one relevant stimulus), such distractor interference is eliminated when the task performed involves higher perceptual load (e.g. involving six or more stimuli, see Lavie, 2005 for review).

In order to examine how this theory relates to distractibility in everyday life we assessed how the effects of perceptual load on the individual magnitude of distraction in the laboratory relate to the extent to which each individual is likely to be distracted in daily life. The latter was measured with the Cognitive Failures Questionaire (CFQ, Broadbent, Cooper, Fitzgerald and Parkes, 1982): the most established measure for individual differences in distractibility in everyday life.

Participants performed a typical perceptual load plus distractor task (e.g. Lavie, 1995; Lavie & Cox, 1997; Lavie & Fox, 2000) requiring them to search for one of two target letters in displays of either low perceptual load (an angular target among circular place holders) or high perceptual load (angular target among five angular nontarget letters). An irrelevant peripheral distractor letter was also present on each display and participants tried their best to ignore it. The irrelevant distractor was either the same as the search-target in the display (compatible conditions) or the same as the other search-target (incompatible conditions). Distractor compatibility effects on target RTs indicate the extent to which people were distracted.

The individual magnitude of distraction under conditions of low and high perceptual load was related to the individual CFQ scores. The CFQ requires the respondent to rate the frequency with which he/she experiences 25 common types of ‘cognitive failures’. For example: How often-

“Do you start doing one thing at home and get distracted into doing something else (unintentionally)? “

“Do you find you accidentally throw away the thing you want and keep what you meant to throw away – as in the example of throwing away the matchbox and putting the used match in your pocket? “

CFQ scores significantly correlate with ratings of the respondents by their spouses (Broadbent et al. 1982). Moreover, CFQ scores remain stable over time (Broadbent et al. 1982) and may even reflect a genetic predisposition, as the correlation of CFQ scores between monozygotic twin pairs is around 0.5, whereas this correlations drops to around 0.25 for dyzogitic twin pairs and 0.2 for parent-offspring pairs (Boomsma, 1998).

Importantly high CFQ scores have been associated with increased frequency of car accidents (Larson & Merrit, 1991), injuries from falling (Larson, Alderton, Neideffer & Underhill, 1997), accidents at work among electrical workers (Wallace &

Vodanovich, 2003) and a clearly less detrimental failure but nonetheless one that detracts from quality of life: losing work when computing (Jones & Martin, 2003). These consequences of high distractibility suggest it is highly important to ask whether high perceptual load can prevent distraction for all people, even those that are highly distracted and are more likely to be involved in various accidents.

We thus sought to establish that: Firstly, individual differences in the likelihood of daily-life distractibility relate to the individual magnitude of distraction in our laboratory task. Specifically, people that score high on the CFQ measure of daily-life distractibility were also expected to suffer from greater distractor effects in our task. Secondly, if high perceptual load can eliminate distraction for all, then, compared to those with low CFQ scores, individuals with high CFQ scores should show greater interference from the irrelevant distractor in conditions of low perceptual load but not in conditions of high perceptual load.

# Method

## Participants

Sixty one volunteers (33 females) aged 19 to 38 years old (M = 25) from UCL subject pool participated in exchange for £4.Two participants ( one male) had 45% and 43% error rates in the high load condition and were therefore excluded from the analyses.

## Stimuli & Procedure

Participants performed a perceptual load task closely based on Lavie & Cox (1997, Experiment 1, see also Lavie, 2005 for a stimulus figure). E-prime was used to present the stimuli on a 15 inch computer screen placed 60 cm away from the participants. Each trial started with a 500 ms presentation of a central fixation point immediately followed by a 100 ms presentation of the task display. The task display consisted of a circle of six letters centered at fixation with a 1.6$^{o}$ radius, plus a peripheral distractor letter, presented to the left or right of the circle, 1.4$^{o}$ away from the nearest central circle letter. All the stimuli were presented in white on a black background. Each of the circle letters subtended 0.6$^{o}$ by 0.4$^{o}$ and the distractor letter subtended 0.8$^{o}$ by 0.5$^{o}$. The search targets were X or N. Each letter-circle contained one target and the participants were instructed to indicate which of the target letters was present in the circle by pressing either the ‘0’ or the ‘2’ key on numerical pad of the computer as fast as possible while not sacrificing accuracy. The distractor letter was equally likely to be X or N and the participants were instructed to ignore the distractor. In the high load condition, the letters H, M, K, Z, W were placed randomly in the nontarget circle positions in a different order on each trial. In the low load condition the nontarget letters were all small Os (0.15$^{o}$). Target position, distractor position and identity, and their combinations were counterbalanced.

Following three slower example trials and twelve practice trials from each load condition, participants completed eight low load and high load blocks of 96 trials each in an ABBAABBA order. The Cognitive Failures Questionnaire (Broadbent et al., 1982) was then administered.

## Results

Within-subject two-way ANOVAs of the correct RTs within 100 ms to 1500 ms and error rates showed significant effects for load ($F(1, 58) = 224.988$, $p < .001$, $p_{rep} > .99$, $\eta_p^2 = .795$ for RTs; $F(1, 58) = 86.725$, $p < .001$, $p_{rep} > .99$, $\eta_p^2 = .599$ for errors), distractor compatibility ($F(1, 58) = 77.463$, $p < .001$, $p_{rep} > .99$, $\eta_p^2 = .572$, for RTs; $F(1, 58) = 45.228$, $p < .001$, $p_{rep} > .99$, $\eta_p^2 = .438$, for errors) and their interaction, ($F(1, 58) = 38.528$, $p < .001$, $p_{rep} > .99$, $\eta_p^2 = .399$, for RTs; $F(1, 58) = 11.610$, $p < .001$, $p_{rep} > .99$, $\eta_p^2 = .167$, for errors.) As can be seen in Figure 1 this interaction reflected that distractor compatibility effects were greater in the low load condition (for RTs, compatibility effect M = 28 ms, t (58) = -11.109, $p < 0.001$, $p_{rep} > .99$, *d* = -2.89; for errors compatibility effect M = 4.3%, t (58) = 7.417, $p < 0.001$, $p_{rep} > .99$, *d* = 1.95) than in the high load condition (for RTs, compatibility effect M = 6 ms, t (58) = -2.267, p = .027, $p_{rep} = .91$, *d* = -.60; for errors compatibility effect M = 1.7%, t (58) = 2.889, p =.005, $p_{rep} =.97$, *d* = .76 ). These findings provide a replication of the previous findings that perceptual load significantly reduces distractor effects (e.g. Lavie & Cox, 1997).

Individual differences

Participants were divided into high CFQ group versus low CFQ group with a median split of the CFQ scores (range = 19 - 82, median= 41, SD = 13.87) and a mixed model RT ANOVA with the between-subject factors of CFQ group and the within-subject factors of load and compatibility revealed no significant main effect of CFQ group (F (1, 57) = 2.414, p >.10, $p_{rep} = .791$, $\eta_p^2 = .041$) and no interaction between load and CFQ group (F < 1). These results indicate that the CFQ groups did not differ in their search performance or in the effects of load on search. Importantly, there was a significant interaction between distractor compatibility and CFQ group, F (1, 57) = 4.670, p <.05, $p_{rep} = .90$, $\eta_p^2 = .076$, indicating greater compatibility effects for the high CFQ group than the low CFQ group.

Critically, this interaction was qualified by a three-way interaction between distractor compatibility, load and CFQ group, F (1, 57) = 4.831, p < .05, $p_{rep} = .905$, $\eta_p^2 = .078$. As predicted by the hypothesis that high perceptual load can eliminate distractibility for all people and as can be seen in Figure 2, distractor compatibility effects were greater for the high CFQ than the low CFQ group in the low load condition (t (57) = -3.3, $p < .01$, $p_{rep}$ .979, *d* = -.88), but not in the high load condition (t < 1).

This result pattern was also characteristic of the correlations: CFQ score positively correlated with the magnitude of distractor compatibility effect under low perceptual load (Spearman $r_s = .22$, $p < .05$, $p_{rep} = .88$, one-tailed), but not under high perceptual load (Spearman $r_s = .025$, $p > .4$, $p_{rep} = .55$, one-tailed).

The error results were not sensitive to reveal any effects or interactions with the CFQ groups (apart from a nonsignificant trend towards an interaction of CFQ and load, F (1, 57) = 3.1, p = .083, $p_{rep} = .836$, $\eta_p^2 = .052$, suggesting the increase in load to have generally been more detrimental to the accuracy of the high CFQ group than the low CFQ group, all p's > 0.1).

## General Discussion

The present study establishes two important findings: Firstly, people who report being more distracted in every-day life also show greater distraction in our laboratory task: Irrelevant peripheral distractors produced a greater magnitude of response-competition effects for people with high (compared with low) scores on the CFQ measure of distractibility in daily life.

This finding is important as the previous studies that assessed the relationship of CFQ and distractor effects in selective attention tasks (e.g. response-competition, Stroop-like, or negative priming tasks, Broadbent, Broadbent & Jones, 1986; Kramer et al, 1994; Martin, 1983; Tipper & Baylis, 1987; Vom Hofe, Mainemarre & Vannier, 1998; Bloem & Schmuck, 1999; Kane et al, 1994) have produced mixed results, have often used small samples, or mixed young and elderly populations and have not always precluded the possibility of eye movements in the task (see Larson & Perry, 1999, for the association of CFQ and control of eye movements). By contrast here we establish that high CFQ is associated with greater distractibility in a large sample of young adults with brief display durations (100 ms) that preclude alternative accounts for the effects of attention in terms of eye movements (see e.g. Fischer, 1987). These findings suggest that our task can be used to predict the extent to which people are likely to be distracted in everyday life on the basis of the magnitude of distractor effects in the conditions of low perceptual load.

Secondly, the significant interaction found between perceptual load, distractor compatibility and CFQ indicated that people who report being more distracted in every-day life show more distractor interference in tasks of low perceptual load but not in those of high perceptual load. High perceptual load reduced distractor interference for all participants, high and low CFQ scorers alike, to the extent that individual differences were eliminated. These results are the first to establish the effects of perceptual load on individual differences in the likelihood of distractibility in every-day life and suggest perceptual load is a potent and universal determinant of distractibility.

In addition to adding external validity to load theory, the findings also suggest an important implication for daily life. Poor selective attention has been shown to impact negatively everyday life not only in terms of increased risk of careless errors and accidents (as discussed in the introduction) but also in terms of academic failure – for example teacher ratings of school children's attention, but not other problems such as anxiety or oppositional behaviour, have been shown to predict diminished academic achievement (Rabiner et al, 2004). Our findings that high perceptual load in a task reduces distractibility for all people, high or low CFQ scorers alike, suggests that modifications of daily tasks so that they involve high perceptual load may prove very useful for all, even those that are highly distracted. For example, teachers and lecturers may be able to reduce the susceptibility of their audience to distraction from irrelevant information (e.g. other people (or children in schools settings) passing by the window) by supplementing verbal explanations with increased task-relevant visual information (e.g. hand gestures, colorful presentations). Such modifications could prove particularly beneficial (e.g. enhance academic achievements) for those with poor attentional ability that typically suffer from a high level of susceptibility to distraction.

References

Bloem, R., & Schmuck, P. (1999). Individual differences in cognitive inhibition and their relation to failures of attention. Diagnostica , 45, 47-55

Boomsma, D.I. (1998) Genetic Analysis of Cognitive Failures (CFQ): A study of Dutch adolescent twin pairs and their parents. European Journal of Personality. 12, 321-330

Broadbent, D.E., Broadbent, M.H.P. & Jones, J.L. (1986). Performance correlates of self-reported cognitive failure and of obsessionality. British Journal of Clinical Psychology. 25, 285-299

Broadbent, D.E., Cooper, P.F., FitzGerald, P. & Parkes, K.R. (1982). The Cognitive Failures Questionnaire (CFQ) and its correlates. British Journal of Clinical Psychology, 21, 1-16

Fischer, B. (1987). The preparation of visually guided saccades. Reviews in Physiology, Biochemistry and Pharmacology. 106, 1-35

Jones, G.V & Martin, M. (2003). Individual differences in failing to save everyday computing work Applied Cognitive Psychology. 17, 7 861-868

Kane, M.J., Hasher, L., Stoltzfus, E.R., Zacks, R.T. & Connelly, S.L. (1994) Inhibitory attentional mechansims and aging. Psychology and Aging. 9(1), 103-112.

Kramer, A.F., Humphrey, D.G., Larish, J.F., Logan, G.D. & Strayer, D.L. (1994) Aging and inhibition: Beyond a unitary view of inhibitory processing in attention. Psychology and Aging, 9(4), 491-512

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: An International Review, 40, 37-45.

Larson, G.E. & Perry, Z.A. (1999). Visual Capture and Human Error. Applied Cognitive Psychology, 13, 277-236

Lavie, N. (1995). 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. & Cox, S. (1997) On the efficiency of attentional selection: Efficient visual search results in inefficient rejection of distraction. Psychological Science, 8, 395-398.

Lavie, N., & Fox, E. (2000) The role of perceptual load in negative priming. Journal of Experimental Psychology: Human Perception and Performance, 26, 1038-1052.

Lavie, N. Hirst, A., de Fockert, J.W. & Viding, E. (2004) Journal of Experimental Psychology: General, 133, 3, 339-354.

Martin, M. (1983) Cognitive failure: Everyday and laboratory performance. Bulletin of the Psychonomic Society;. Mar, 21(2), 97-100

Rabiner, D.L., Murray, D.W., Schmid, L., & Malone, P. (2004). An exploration of the relationship between ethnicity, attention problems, and academic achievement. School Psychology Review, 33, 498-509.

Tipper, S.P. & Baylis, G.C. (1986). Individual differences in selective attention: The relation of priming and interference to cognitive failure. Personality and Individual Differences, 8(5), 667-675.

Vom Hofe, A., Mainemarre, G., & Vannier, L. (1998). Sensitivity to everyday failures and cognitive inhibition: Are they related? European Review of Applied Psychology, 48, 49–55

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 (4), 503 - 514

_Figure Caption

Figure 1. RTs (left panel) and errors (right panel) as a function of perceptual load and distractor compatibility. Error bars represent SE.

Figure 2. Distractor compatibility effects on RTs as a function of perceptual load and CFQ group. I = incompatible C = compatible. Error bars represent SE.

Figure 1

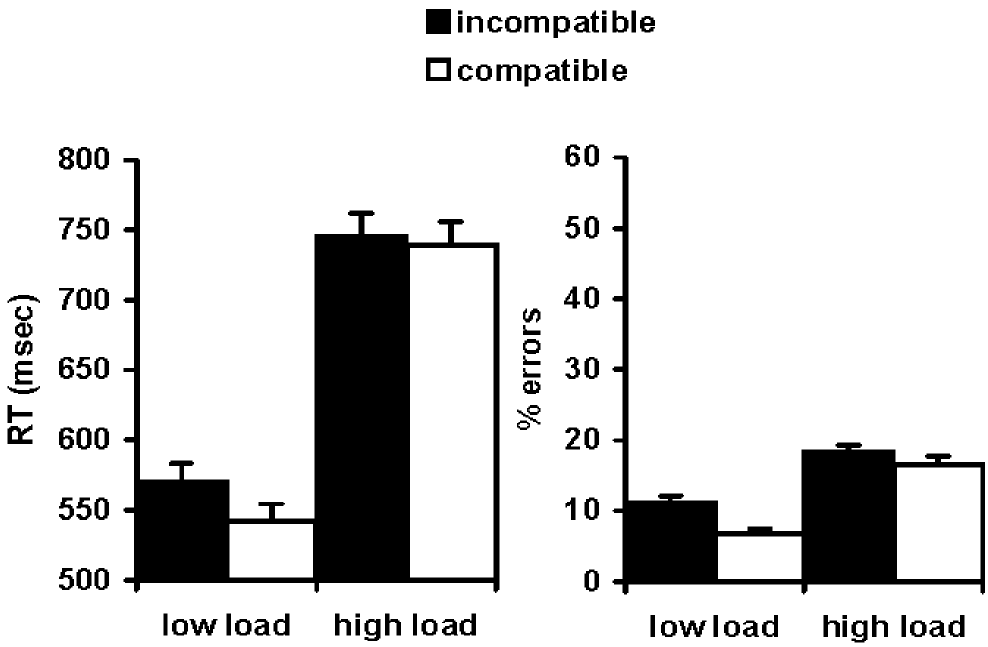
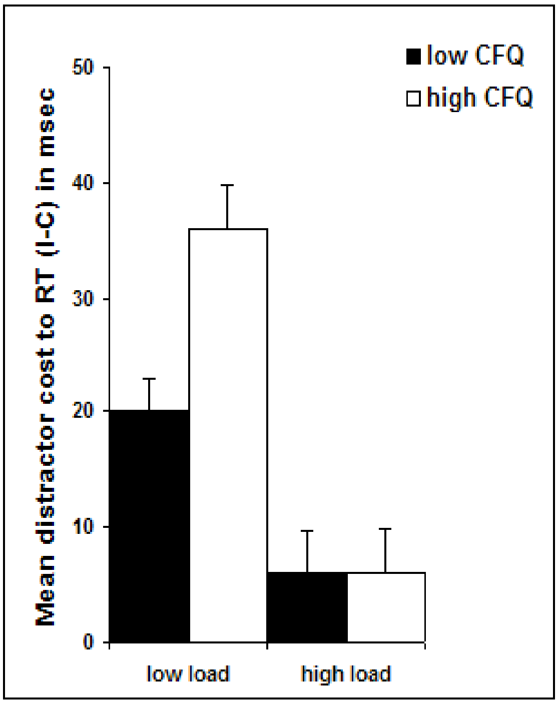

incompatible
compatible
800
750
700
650
600
550
500
RT (msec)
low load
high load
60
50
40
30
20
10
0
% errors
low load
high load

Figure 2


low CFQ
high CFQ
Mean distractor cost to RT (I-C) in msec
50
40
30
20
10
0
low load
high load