INDIVIDUAL DIFFERENCES IN SELF REPORTED COGNITIVE FAILURES: THE ATTENTION HYPOTHESIS REVISITED

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Summary—It is unclear which attention functions are related to self reported cognitive failures [measured with the CFQ (Broadbent, Cooper, FitzGerald & Parks, 1982)]. Experiment 1 showed no significant correlations between CFQ and two perceptual speed tests. In Experiment 2 we identified two attention/control factors. Shifting between action-schemas was not significantly correlated with CFQ. However, frequent cognitive failures were associated with slow performance on focused attention tasks ($r = 0.61$). In Experiment 3 subjects named tachistoscopically presented letters, appearing in one of eight locations along a circular display. In 75% of the trials targets appeared in one of two pre-cued locations. When the cues were adjacent and the Stimulus-Onset-Asynchrony was long (120 msec) subjects zoomed covert visual attention on the cued locations. Report of frequent cognitive failures was significantly associated with greater zooming ($r = 0.45$). Nevertheless, zooming led more to costs than to benefits. The data are discussed in terms of Norman and Shallice's (1986) model of attention control.

INTRODUCTION

People sometimes forget recently introduced names, forget why they opened the refrigerator, accidently throw away a thing they needed and so forth. Psychologists have tried to measure and explain these everyday cognitive failures, distinguished as slips of the tongue (e.g. Dell, 1986) and action slips (Norman, 1980; Reason, 1984). However, some people experience more frequent cognitive failures than others. A popular measure of individual differences in that tendency is the Cognitive Failure Questionnaire (CFQ) developed by Broadbent, Cooper, FitzGerald and Parks (1982). CFQ is a 25-item questionnaire that requires Ss to report, on a 0 (never) to 4 (very-often) scale, the frequency of everyday cognitive lapses during the last 6 months. At face level, the CFQ measures cognitive dysfunctioning. Nevertheless, it is either weakly related or unrelated to objective measures of cognitive functioning such as intelligence and laboratory-memory (Broadbent *et al.*, 1982). Of all performance measures only those measuring attention show correlations with CFQ.

Yet, the relationship between CFQ and attention is a complicated one as some attentional measures are related to CFQ whereas others are not (e.g. Broadbent, Broadbent & Jones, 1986, 1989; Smith, 1991). The fact that the concept of attention serves as a headline for a host of many processes (e.g. Broadbent *et al.*, 1986) adds to this complication. Nevertheless, the high internal reliability of the CFQ (Broadbent *et al.*, 1982) suggests that its items tap a single mechanism or a conglomerate of correlated mechanisms.

One attempt to explain CFQ in terms of a single attentional mechanism was made by Tipper and Baylis (1987). These authors suggested that high CFQ Ss (who report experiencing frequent cognitive failures) are deficient in their ability to actively inhibit distracting information presented to them along with the targets. There are two immediate reasons why this explanation might be inaccurate. First, Broadbent *et al.* (1986) used a reaction-time (RT) task which required Ss to ignore distracting information, but the degree of distractability was not significantly correlated with CFQ. In addition, Martin (1983) reported insignificant correlations between CFQ and the Stroop Colour Naming Test [see MacLeod (1991) for a review]. Martin's finding is especially troublesome for Tipper and Baylis's theory, as the Stroop test is probably *the* paradigmatic case in which active suppression of irrelevant information is required. In that test Ss are asked to name the ink in which colour-names are written

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while ignoring the colour-names themselves. Tipper and his associates (Tipper, 1985; Tipper & Cranston, 1985), Neill and his associates (e.g. Neill, 1977; Neill & Valdes, 1992; Neill & Westberry, 1987) and Lowe (1979) suggested that Ss who perform the Stroop task actively suppress the irrelevant information. The position is that either Tipper and Baylis's theory needs some qualification or that another, yet unidentified attentional mechanism underlies individual differences in everyday cognitive failures and not active inhibition.

In order to examine the relationship between attention and CFQ we adopted a top-down strategy. First, we analysed the content of the 25 CFQ items according to the taxonomy of action slips provided by Norman (1980). This taxonomy was later developed into a full model of cognitive control by Norman and Shallice (1986, see also Shallice, 1988). Norman and Shallice's model assumes a hierarchy of control functions. At the lower level behaviour is controlled by action schemas. However, a higher level which selects action schemas is required when Ss stop doing what they currently do and shift to a new task. The selection of action schemas is performed either autonomously, through schema competition in the 'contention schedular', or by a central Supervisory-Attention-Mechanism (SAS).

Classifying the CFQ items was a difficult task, as some items were sorted into two categories instead of just one. Therefore, we counted the number of items in each category while splitting the weight of ambiguous items between the two categories into which they were classified. An equivalent of 10 items were classified into the 'loss of activation' category (e.g. item 23: "Do you find you forget what you came to the shops to buy?"); seven items into "false triggering of action schemas" (e.g. item 10: "Do you lose your temper and regret it?"); four-and-a-half items into "failure to trigger action schemas", two-and-a-half into "Unintentional activation of schemas", and one was unclassified.

At the next stage we tried to generate hypotheses regarding a common mechanism behind these categories of cognitive failures. Employing Norman and Shallice's (1986) model, we suggest two possible common mechanisms underlying high-CFQ scores: triggering efficiency and distractibility. According to the triggering efficiency hypothesis, weak activation of the intended schemas leads to slowing of the schema selection process in the contention schedular. This state of affairs is likely to cause failures in executing the intended action and is also likely to cause the execution of highly automated but unintended actions instead. The distractibility hypothesis suggests that high-CFQ Ss are more distractible by irrelevant information than low-CFQ Ss. The distracting information sometimes leads to the activation of unintended schemas which, in turn, causes loss of activation from the intended schemas. The linking of distractability on the one hand and low or loss of activation, on the other hand, is based on an analogy with the processes of comprehension, as described by Gernsbacher and her associates (Gernsbacher, 1991; Gernsbacher & Faust, 1991; Gernsbacher, Varner & Faust, 1990). According to Gernsbacher, distraction leads to the loss of activation (forgetting) from the currently attended comprehension structure (an analogue of a schema). The distractibility hypothesis is very similar to Tipper and Baylis's (1987) model, according to which cognitive failures are caused by Ss' inability to suppress irrelevant information. However, distractibility is a more theoretically neutral term than active inhibition. Specifically, Ss can avoid potential distraction from irrelevant information using processes other than active inhibition, such as attentional zooming (Eriksen & St James, 1986; Eriksen & Yeh, 1985), as described more fully in Experiment 3.

All the three experiments reported below were conducted with Israeli Hebrew-speaking Ss. Therefore, the first experiment tested the psychometric qualities of the Hebrew translation of the CFQ. Experiment 2 tested the triggering efficiency hypothesis and Experiment 3 tested a corollary of the distractibility hypothesis.

EXPERIMENT 1

Experiment 1 was designed to examine the psychometric characteristics of the Hebrew translation of the CFQ. The Ss were also tested on a Hebrew group intelligence battery [IDAT (Fischman, 1982)]. Broadbent et al. (1982) reported low correlations between intelligence and CFQ. Nevertheless, IDAT includes measures of perceptual speed and a speeded Number-Addition test. Perceptual speed is conceptually related to visual attention. Number-Addition is interpreted by clinicians as measuring

Table 1. Pearson product-moment correlations between the group intelligence tests and CFQ: Experiment 1

Test	Reliability		Correlations		
	Internal	Retest	Males	Females	Total
Vocabulary	0.89	0.80	0.19	0.02	0.04
Comprehension	0.89	0.74	− 0.09	− 0.02	− 0.10
Culture—Fair					
(Cattell, 1960)	0.86	0.71	− 0.06	− 0.11	− 0.12
Visualization	0.90	0.79	0.03	− 0.19	− 0.09
Mechanical reasoning					
[DAT (Bennett,					
Seashore & Wesman, 1961)]	0.80	0.86	0.11	− 0.18	− 0.03
Quantitative					
Reasoning	0.86	0.76	− 0.04	− 0.24	− 0.21*
Memory	0.79	0.50	− 0.14	− 0.17	− 0.14
Letter cancellation	0.75	0.70	0.09	− 0.01	0.07
Number cancellation	0.55	0.74	0.02	0.09	0.02
Vertical addition	0.85	0.81	− 0.05	0.08	− 0.02
Symbol digit	0.86	0.80	− 0.00	0.12	0.08

*$P < 0.05$, two-tailed test.

concentration. Therefore, the results of Experiment 1 also provided some additional information about the relationship between CFQ and attention/concentration.

Method

Subjects

One-hundred and thirty-eight junior high and high school students who were tested for counselling purposes. The distribution of Ss according to grade level and age is as follows: 8th grade ($F = 3$, $M = 6$), 9th grade ($F = 49$, $M = 64$) and 10th grade ($F = 5$, $M = 11$). All the Ss were Hebrew speakers.

Tests and procedure

The Ss first completed the 11 subsets of the IDAT and then gave their answers to 23 of the 25 CFQ items, translated into Hebrew. Two CFQ questions were not used because of their inapplicability to this population (questions 3 and 11, that refer to driving and failing to respond to important letters).

Results

The internal reliability of CFQ was high as indicated by Cronbach's $\alpha = 0.87$. ($M = 32.0$ and $SD = 11.0$). Taking into account that the questionnaire was shortened by two items, the present mean is equivalent to 34.8 ($SD = 12.0$). Similar descriptive statistics were reported by Broadbent et al. (1982) for production workers and skilled men. Of the eight groups reported by Broadbent et al. (1982) these were the two having the lowest mean CFQ scores. The internal reliability that we found is equivalent to $\alpha = 0.88$ with a 25 item-scale (as estimated by the Spearman–Brown formula). In comparison, Broadbent et al. (1982) reported an α of 0.89.

To control for age and Hebrew proficiency, the correlational analyses (Table 1) were conducted on the data of 90 9th-graders ($M = 49$, $F = 41$) for whom Hebrew was their mother-tongue and who had complete intelligence test data.

As can be seen, 20 correlations were in the expected negative direction while 13 were positive in sign. Only one correlation reached significance indicating that high-CFQ Ss, who reported experiencing frequent cognitive failures, performed worse on the Quantitative-Reasoning subset of IDAT, as compared to low-CFQ Ss. However, this tendency was found only among female Ss. The trend of low negative correlations between intelligence and CFQ agrees with what had been reported by Broadbent et al. (1982).

Clinical psychologists often interpret the Number-Addition test as indexing concentration ability. Many CFQ questions describe absent minded behaviour indicating lack of concentration. However the insignificant correlation, $r = − 0.02$ between Number-Addition and CFQ does not confirm the interpretation of the Number-Addition as a concentration test. We do not wish to make too much of this finding since the psychometric literature (reviewed by Ekstrom, French & Harman, 1976) refers

to Number-Addition as measuring "Number Facility" (Ekstrom *et al.*, 1976, p. 115). The cancellation tests are classical 'perceptual-speed' tests (Ekstrom *et al.*, 1976). Perceptual-speed should be related to visual-attention. Nevertheless the correlations between the perceptual-speed tests and CFQ were close to zero.

In conclusion, Experiment 1 showed that as far as the reliability, mean, and the correlations with intelligence are concerned, the Hebrew version of the CFQ is nearly equivalent to the original English version. The experiment also showed that the attentional functions measured by 'perceptual-speed' tests were not significantly related to CFQ.

EXPERIMENT 2

According to the triggering hypothesis, weak activation of intended action schemas is the common source of most CFQ slips. In order to measure schema activation efficiency we used tasks which required *S*s to quickly shift between alternative action modes. Shift time was interpreted as resulting from schema triggering, with slower shifts associated with weaker schema activation. Allport, Styles & Hsieh (1994) have recently shown RT switch costs in tasks that required *S*s to shift from one action schema to another. For example, in one experiment *S*s were presented with groups of identical digits (e.g. '2 2 2'). They were required to refer to two different stimulus dimensions: the group size (three, in the example), or the value of the digits (two, in the example). Furthermore, *S*s made two kinds of judgment: (1) is the result odd or even, (2) is the result greater or smaller than five. *S*s were tested on baseline conditions in which all the judgments were of the same kind and on conditions which required continuous shifting between stimulus dimensions or between judgement types. Allport *et al.* (1994) found that Performance was slower compared to baseline when shifts were required regardless of shift type [see Bernstein (1924), Jersild (1927) and Jones (1915), cited by Bernstein (1924), for examples of early uses of this paradigm].

It seemed to us that any given shift cost can be explained in task specific terms, as exemplified for the Global/Local task below. Therefore, we decided to use three very different tasks, as converging operations. A confirmatory Factor Analysis was used to establish the external validity of the shift-time estimates. In each of the tasks the performance speed under shift conditions was compared to that under baseline conditions. The Global/Local task was adopted from Navon (1977). *S*s were required to name letters composed of small different letters (e.g. the Hebrew letter 'MEM' composed of small 'GIMAL' letters). In the Global condition we asked the *S*s to name the large letter while ignoring its components. In the Local condition *S*s were required to name the component letters while ignoring the global letters. These two conditions served as baseline for the critical condition where *S*s continuously shifted from global to local modes. Ward (1982) found that *S*s were slower when the previous judgement was made at different level (global after local or vice versa) than if both the current and the previous judgement were made at the same level (global after global or local after local). Ward explained his results in terms of 'level readiness', namely, that slowing on switching trial was caused by the fact that when *S*s respond at a given level (global or local) they automatically setup their readiness for that level. Consequently, they were less efficient when switching to the other level. Shifting between local and global modes may be explained in terms of zooming and looming of visual attention (Eriksen & St James, 1986; Eriksen & Yeh, 1985), which does not necessarily involve a central schema selection mechanism. However, if shift time in the Global/Local task will be correlated with shift times estimated from non-spatial tasks then the more reasonable explanation should involve a central schema selection mechanism.

The Colour-Target task was adopted from Allport, Tipper and Chmiel (1985). *S*s were presented with coloured, partly overlapping letter pairs. They were required to name the letters written in one colour while ignoring those written in another colour. In the critical condition *S*s continuously shifted from one target colour to another.

In the Category-Generation Task *S*s vocally generated exemplars to visually presented category names. In the Slow-Shift condition there were three categories, such that each category was repeated three times in a row. In the Fast-Shift condition there were nine categories per card, such that each category appeared only once. Hence, the Fast-Shift condition required *S*s to shift from one category

to another on every stimulus, whereas the Slow-Shift condition required shifting on every third stimulus.

The triggering-efficiency hypothesis predicts that Ss, who are relatively fast shifters in one task, will also be fast shifters in the other two tasks as well. This hypothesis also predicts a correlation between shifting efficiency and CFQ. To obtain discriminant validity for our shift measures, we compared them to their baseline (non-shift) conditions. All baseline conditions required Ss to focus on one aspect of the stimulus while ignoring another aspect. In the Global (Local) task they should have ignored the local (global) stimulus. In the coloured letter task they should ignore the letters of the other colour. In the category generation task they should have ignored the other category names presented next to the category name to which they responded. In other words, the present set of tasks taps two distinct attentional functions: shifting-speed and focused-attention performance speed. However, the triggering hypothesis predicts that only shifting-speed will correlate significantly with CFQ.

Method

Subjects

Forty Bar-Ilan University students (21 men and 19 women) participated as volunteers. The data of five additional Ss who failed to comply with the instructions were dropped. All Ss reported normal or corrected vision, normal colour vision and full mastery of Hebrew.

Experimental tasks

In all the three tasks, performance duration was measured with a manual stop watch (0.10 sec accuracy). Ss completed the full CFQ (25 items) as their last task.

Global-Local. Three tasks were used, the Global task required Ss to read aloud the large letter (global-instructions); the Local task required Ss to read the small letter comprising it (local instructions). In the Global/Local task Ss were required to continuously alternate between global and local instructions. Thirty-two column-lists were used, each containing 10 large Hebrew letters (2.5 × 2.5mm) composed of 9–17 different small Hebrew letters (2 × 3mm) written in black ink with 'Linero' graphics-ruler on a white 11 × 34cm sheet of Bristol paper. The gap between two adjacent large letters was 12mm and between adjacent small letters 2mm. Nine visually distinct letters from the Hebrew 'print' (DFUS) alphabet served throughout and were randomly allocated to positions. In eight lists the large letters were enclosed by a red line, whereas in eight other lists one small letter was so marked. In the remaining 16 lists, letters were interchangeably marked, such that in one the large letter was marked while in the succeeding large letter a small component-letter was marked and so forth. Ss were asked to read aloud as quickly as possible, the letters that were marked by the red-line. Marking was used to minimize memory load on the shift conditions (e.g. Dark, 1990). Instructions stressed accuracy. Errors were recorded on-line by the experimenter and overall oral response time was separately measured for each list, using the hand stop-watch. Task ordering was the same for all Ss and as follows: global instructions (four lists of which the first served for practice), Local instructions (four lists of which the first was practice), Shift instructions (16 lists of which four were practice), Local instructions (4, 1 practice) and Global instructions (4, 1 practice). In this way the average order-position of the lists was the same for the three tasks.

Colour-target. Ss received vertical lists containing letter pairs. In each letter pair the lower letter was always written in one colour and the upper in another colour. In the non-shift conditions Ss were required to read aloud all the letters written in a given colour. In the shift conditions they were required to read the letter written in one colour in the first pair, the letter written in the opposite colour in the next pair and so forth.

The stimuli were 19 column lists of coloured partially overlapping (about 25%) Hebrew letter-pairs written on Bristol-paper of 17 × 25cm and separated vertically by 6mm. In each pair, the upper letter partly overlapped with the upper left corner of the lower letter. Ten lists contained green lower-right letters and red upper-left letters. In the remaining nine lists the lower letter was blue and the upper orange. Opponent colour pairs were used to make the colour distinction easy. Seventeen of the 22 letters of the Hebrew alphabet were used. Each list contained 15 pairs of letters, each 4 × 6mm such that the pair size was 6 × 9mm. To prevent inhibition or excitation effects (e.g. Allport *et al.*, 1985),

Table 2. Descriptive statistics (in msec per item) and reliabilities: Experiment 2

Measure	M	SD	Reliability (α)
Global/Local			
1. Global	619	156	0.94
2. Local	461	90	0.87
3. Shift	758	172	0.96
Colour–Target			
4. Focused	409	56	0.87
5. Shift	642	204	0.98
Category Generation			
6. Slow	1319	288	0.90
7. Fast	2056	382	0.88
8. CFQ†	33.4	14.7	0.88‡

*$P < 0.05$, two-tailed test.
†In terms of scale scores.
‡As estimated in Experiment 1.

the two letters in each pair were never identical, and none of them was identical to a letter appearing in the previous pair.

We told the Ss that their task was to read aloud, as quickly as possible but without errors, the letters printed in a given colour. Conditions were ordered as follows: non-shift (two practice lists such that green was the target colour in one list and blue was the target colour in the succeeding list. These were followed by two lists, both of which contained blue targets); four practice lists on the shift conditions (green–red, blue–orange, blue–orange, green–red) followed by three green–red shift lists; two non-shift green–red lists; one practice shift blue–red list followed by three blue–red shift lists and concluding with two non-shift lists, one green–red the other blue–orange. In sum, there were six non-shift lists and six shift lists, such that half of each type were of different target-colour combination. As before, the average order position of the lists was the same for the two conditions.

Category Generation. The task required Ss to orally generate an exemplar of a visually presented category word. In the slow-shift condition the category word was repeated three times before shifting to the next category word. In the fast shift condition each category word was presented only once. The stimuli were 16 lists, each containing nine category words, written with a 'Linero' graphics ruler with letters subtending 4 × 6mm. Category words were vertically spaced by a 10mm gap and were written in black on white Bristol paper 17 × 25cm in size. The mean number of syllables per category name was nearly identical across lists. Category names were taken from Henik and Kaplan (1989) norms, such that each selected category had at least three exemplars which were generated by more than half of the normative-sample Ss. Some category names were added to the fast-shift lists, that did not appear in Henik and Kaplan norms but seemed to have one exemplar that is likely to be generated by most of the Ss. Each of the slow-shift conditions contained three category-names, each repeated three times. In the fast-shift conditions each list contained nine different category names.

When tested, Ss were instructed to orally generate, as quickly as possible, an exemplar of the given category. Ss were first tested on the slow then on the fast shift conditions. The first (of nine) lists in each condition served for practice.

Results

As predicted, performance times were longer on the shift, compared to the non-shift conditions. We also identified two unrelated attention/control factors corresponding to shift time and to focused attention performance time. Contrary to the triggering efficiency hypothesis, the shift time factor was unrelated to CFQ whereas the focused attention factor was.

Performance times were divided by the number of responses to yield time-per-item scores. Preliminary analysis found that for the Category-Generation and the Global/Local tasks, most responses were fast but few exceeded 10 sec. Similarly, for the target-colour shift task wild scores were defined as those exceeding 7 sec. For each S we computed the mean item-time separately for each condition. This mean was determined after excluding wild scores, and served as their replacement. Table 2 presents the descriptive statistics and the internal reliabilities of the task scores.

For each S we computed a shift score separately for each task. All the mean shift scores were

Table 3. Confirmatory factor analysis pattern (standardized maximum-likelihood coefficients) of the Focused/Shift Model: Experiment 2

Measure	Factor loadings	
	Focused attention	Shift
Global	0.83*	
Local	0.78*	
Colour–Target	0.22	
Slow Category Generation	0.64*	−0.12
Global/Local shift		0.86*
Colour–Target shift		0.27
Category Generation shift		0.57*

Factor	Factor Correlations	
Shift	0.06	
CFQ	0.61*	−0.04

*$P < 0.05$, two-tailed test.

significantly different from zero. In the Global/Local task the shift was defined as the difference between the shift and the mean of the global and the local conditions, $M = 218$ msec, $SD = 124$ msec, $t(39) = 11.12$, $P < 0.0001$, two sided test. The fact that global responses were slower than local responses is opposite to what is usually obtained with the Global/Local task (e.g. Navon, 1977). However, it is known that the global superiority can be reversed under certain conditions (see Kimchi, 1992, for a review). For the Colour–Target task the mean shift time was $M = 233$ msec ($SD = 197$ msec), $t(39) = 7.48$, $P < 0.0001$, two sided test. For the Category-Generation task the fast minus slow shift score was multiplied by 1.5 because the fast condition required one shift per-item whereas the slow condition required an average of one third of a shift. Their difference was, therefore, the time to perform two-thirds of a shift. This time was multiplied by 1.5 to obtain time per shift estimate. Shift time in the category task was much larger than that of the two previous conditions: $M = 1106$ msec, $SD = 429$ msec, $t(39) = 16.31$, $P < 0.0001$.

We performed a maximum-likelihood confirmatory Factor-Analysis [using SAS CALIS procedure (SAS, 1990)] on the covariance matrix of the shift and baseline time data. We tested three competing models: according to the Single-Factor Model all task parameters measure a single attentional ability. According to the Task Model, each task requires a different attentional ability. The Focused/Shift Model makes a distinction between performance under focal attention conditions (baselines) and shifting speed. The correlations between CFQ and attention factors were also estimated. If two or more parameters are extracted from the same tasks they may correlate for reasons associated with the extraction procedure. Consequently, including both the baseline times and the shift parameters in the same analysis, as we did, could have lead to the identification of factors which tell very little about the psychological processes involved. However, these factors should have been related to tasks, as suggested by the Task Model, and not to processes as suggested by the Focused/Shift Model. The rejection of the Task Model showed that the results of the analysis were not trivial and established the psychological reality behind the selected Focused/Shift Model.

There was a large and significant discrepancy between the Single-Factor Model and the data, $\chi^2(20) = 64.880$, $P < 0.0001$. That model had also poor Bentler and Bonnet (1980) normed fit index (BBN = 0.181) and low James, Mulaik and Brett (1982) Parsimonious index (PAR = 0.129). The Task Model was better than the Single-Factor Model but was still not satisfactory. Its deviation from the data was significant, $\chi^2(15) = 44.288$, $P < 0.0001$, it had a low BBN = 0.441 and a low PAR = 0.236. The Focused/Shift Model was the best of all three models since its deviation from the data was not significant, $\chi^2(17) = 13.465$, $P = 0.704$, and since it had acceptable BBN = 0.830 and PAR = 0.504. A formal comparison between the fit values showed that both the Task and the Focused/Shift Models fitted the data better than the Single-Factor Model, $\chi^2(5) = 51.415$ and $\chi^2(3) = 20.592$, P's < 0.005. The Focused/Shift Model, presented in Table 3, was better than the Task Model since it fitted the data better with fewer parameters. Consequently, no significance testing was required to prefer the Focused/Shift Model over the Task Model.

The presence of shifting ability was confirmed by the data. However, the loading of Colour–Target

(0.27) on the Focused Attention Factor, despite being in the correct direction, did not approach significance. Similarly, the loading of the Colour–Target Shifting parameter on the Shift Factor (0.22) was insignificant. The Focused and the Shift Factors were nearly orthogonal, $r = 0.06$, N.S., and only performance under focused attention conditions correlated significantly with CFQ, $r = 0.61$, $P < 0.05$. One possibility is that the Shift Factor did not correlate significantly with the Focused Factor and CFQ because of low reliability. In specific, the Shift Factor was based on difference scores, which are usually unreliable (Cronbach & Furby, 1970), as such it had lower chances to correlate significantly with anything. This explanation does not hold in the present case since low reliability also predicts low factor loadings. However, the loadings on the Focused factor were comparable in size to those of the Shift factor. In conclusion, the near-zero correlations of the Shift Factor cannot be attributed to low reliability and to the low power associated with it. Additionally, the Focused factor cannot be interpreted as a general speed factor given that we found in Experiment 1 near zero correlations between CFQ and four speeded tests: Number/Letter Cancellation, Number-Addition and Symbol-Digit.

The shift time estimates obtained in the Colour and the Global/Local tasks were 233 and 218 msec. These values are smaller than those reported by Allport *et al.* (1994), similar to Ward's (1982) 'level readiness effect' and also to the shift times from perception to memory (Dark, 1990; Weber, Burt & Noll, 1986). However, the shift estimates in the category task were much larger, suggesting that other processes were involved in that task.

EXPERIMENT 3

Experiment 2 lent little support to the triggering hypothesis but its results were in line with the distractibility hypothesis. However, the distractibility hypothesis needs some qualification since the ability to ignore distraction is manifested in the Stroop test, and in the Embedded-Figures tests, both of which were not significantly correlated with CFQ (Martin, 1983). The only direct support we know of to the distractibility hypothesis comes from Tipper and Baylis (1987). These researchers found that, compared to low-CFQ, high-CFQ Ss suffered greater costs when the word targets were accompanied by semantically unrelated word distractors. One difference between the Stroop and the Embedded Figures tests on the one hand and the Tipper and Baylis task on the other hand, is the spatial arrangement of the targets and the distractors. In the former, the target and the distractors spatially overlap. In the latter they are spatially separated. This distinction was justified by Experiment 2: when the distracting information was spatially separated (The Global/Local and the Category-Generation tasks), response-times in the baseline conditions correlated with CFQ. However, when they overlapped (the Colour–Target task) this correlation was low and insignificant.

All these considerations suggest that Ss' ability to focus on the target area of the visual display enables them to ignore the distracting information presented in other areas of the display. A very useful analogy in this context is the zoom lens (Eriksen & St James, 1986; Eriksen & Yeh, 1985). According to the zoom lens model Ss can shift between distributed and focused modes of attention. Distribution attention covers a wide area of the visual field but with low resolution. Focused attention results in high resolution but the cost is that it covers only a small area of the visual field. Most important to our discussion is the fact that under focused attention there is no measurable interference from distractors that are placed outside the attentional focus (Eriksen & St James, 1986). Therefore, Ss who quickly zoom their attention on the targets can avoid interference associated with distraction that is spatially separated from the target. However, slow zooming should result in greater distractibility. Some support for this hypothesis comes from Broadbent *et al.*'s (1986) study. In the focused attention condition of this study the targets appeared at the fixation point. The Ss could, therefore, focus their attention in advance. However, high-CFQ Ss gained less from prior knowledge of target location compared to low-CFQ Ss [the SPUL effect in Broadbent *et al.* (1986; 1989) and Smith (1991)]. This finding may suggest that high-CFQ Ss had difficulty in focusing their attention in response to advance knowledge of the target position.

Experiment 3 intended to test the hypothesis that high-CFQ is associated with slow zooming of visual attention. The Ss were tachistoscopically presented with circular arrays of eight evenly separated objects. Seven of them were empty rectangles while the eighth was a target-letter to be

named. Target displays were preceded by displays containing two points, which were either near or far from one another. In 75% of the trials the target appeared in one of the two cued locations. We also manipulated the Stimulus Onset Asynchrony (SOA) between cues and targets. Two SOA values were used: one was very short (10 msec) while the other was longer: 120 msec. These values were taken from Eriksen who found that with similar displays (e.g. Eriksen & St James, 1986; for review) Ss take between 50–200 msec to zoom their attention on the target. Additionally, the SOA between cue and mask was 210 msec, which is normally shorter than the time needed to initiate a saccadic eye movement. Hence, under the present conditions, researchers would normally assume that attention effects do not result from eye movements (e.g., Posner, 1980, for a review).

Based on Eriksen's data, we predicted no cue effects in the short SOA and the far-cue conditions, both of which do not allow for focusing. Short SOA does not allow enough time for the Ss to shift from distributed to focused attention. When the cues are far from one another the subjects must maintain a distributed attention mode. This is so because the attentional focus is too small to include both cues. However, near cues should improve performance if SOA is long enough. Cue effects will be reflected in faster RT's to targets appearing in cued positions (Valid) as compared to targets appearing in uncued positions (Invalid). Zooming speed was estimated as follows. First only near cue data were considered (no focusing of attention is predicted for far cues). Cue effects were computed for the short and the long SOA. The difference in cue effects was interpreted as zooming speed, since it increased with SOA. We used the data of the far-cue conditions as baseline after making sure that there were no cue effects there. Zooming *benefits* were defined as faster RT's on the Valid trials compared to the baseline. Zooming *costs* were defined as slower RT's on Invalid trials compared to the baseline.

If high-CFQ Ss fail to focus their attention we expect them to exhibit slow zooming coupled with diminished cue effects on the near-cue conditions (and long SOA). If, however, high CFQ Ss zoom, but fail to benefit from zooming, we expect them to differ from low CFQ-Ss on focusing-costs or focusing-benefits. That is, high CFQ-Ss were predicted to either have larger costs, or smaller benefits, as compared to low CFQ Ss.

Method

Subjects

Thirty introductory psychology students from Tel-Aviv University (16 females and 14 males) participated for course credit. All Ss reported normal or corrected vision. The data of one female S, who made frequent errors, were dropped from all the analyses.

Apparatus and stimulis

Ss were tested with a Gerbrands four-field tachistoscope model G1135 T-4A. The reaction times were measured to 1 msec accuracy with a microphone and a voice-key attached to an Apple-2E computer through a G1157 interface. Four fields were used: the first, fixation, contained a single central dot, which occupied a visual angle of 0.15°. The last, masking, was a random dot pattern. The second field presented the location cue cards, and the third presented the target cards.

Cues and targets were located on eight evenly spaced locations along an imaginary circle placed in the middle of the card. The cues were two black dots, each occupying a visual-angle of 0.15°. The near cue dots were positioned at two adjacent locations along the circle circumference (45° of the circle). The far cues were placed at two locations separated by two other locations (135° of the circle). The near cues were separated by a visual angle of 2.29°, and the far cues were separated by a visual angle of 5.18°. All the cues were placed outside the imaginary circle, such that their distance from the nearest target object was 0.38° of visual angle. In the target cards, seven of the eight locations were occupied by empty vertical rectangles subtending a visual angle of 0.31° × 0.22°. The eighth position was occupied by the target letter (The Hebrew letters 'ALEPH' or 'BET'), which subtended a visual-angle of 0.38° × 0.38°. The dots, letters, and squares were all drawn in black ink. Target and cue cards were drawn such that they evenly occupied all possible locations. The radius of the imaginary circle subtended a visual-angle of 2.47°, when measured from the most distant point of the letter or empty-square. The ALEPH and BET letters were equally likely to appear.

Table 4. Reaction times (msec) and errors (percentages) according to condition: Experiment 3

	Near-cues		Far-cues	
	Short-SOA	Long-SOA	Short-SOA	Long-SOA
	Invalid Cues			
RT	646	666	655	646
	(92)	(107)	(88)	(95)
Error (%)	9.9	9.1	10.3	10.8
	(10.1)	(12.1)	(10.1)	(11.1)
	Valid Cues			
RT	639	642	652	649
	(83)	(80)	(90)	(82)
Error (%)	7.3	9.6	9.6	8.2
	(6.8)	(7.9)	(8.8)	(7.7)
	Validity-Effects			
RT	7	24	3	3
Error (%)	3.3	4.8	1.3	3.4

Standard deviations appears in parentheses.

Procedure

Ss were tested individually and completed the full 25-item CFQ as their first task. The reaction time task was described as measuring visual acuity. Ss were told that at each trial two cues will appear, such that the target will be located next to one of them in 75% of the trials. After 25 practice trials, we tested the Ss on two trial-blocks, the first with long and the second with short SOA. Each SOA block contained 128 trials, such that in 64 (48 valid 16 invalid) the cues pointed to nearby locations, and in the remaining 64 trials they pointed to distant locations. The same random ordering of trials within block served all the Ss. Each trial consisted of fixation (1000 msec), cue (10 msec) empty Inter Stimulus Interval (0 or 110 msec), target (90 msec) and mask (200 msec).

Results

High CFQ Ss employed the cue information to a greater extent than low CFQ Ss. However, Ss who used the cues suffered more costs than gained benefits.

The mean CFQ was 35.6 (SD = 11.9). The median reaction time and the error proportion for each of the eight experimental conditions were computed separately for each S. One S, who made many errors, was dropped from all the analyses. Table 4 presents the group means of the S cell medians.

The first analysis tested if Ss zoomed on the cued locations. Focusing attention should result in validity effects, defined as reaction time advantage of targets, presented at the cued location (Valid), compared to those presented at the opposite-to-cued locations (Invalid). Eriksen and St James have shown that attentional zooming takes time. It follows that validity effects should increase with SOA. We formed a contrast which compared the validity effect at short SOA to those at long SOA. This analysis was conducted on the near-cue data, since far-cues should not allow for focusing. As predicted, validity effects increased by 15 msec with increased SOA, $F(1, 27) = 4.60$, $P < 0.05$. However, contrary to the zooming-speed hypothesis, high-CFQ Ss showed larger zooming effects than low-CFQ Ss, $F(1, 27) = 6.90$, $P < 0.05$. $r = 0.45$. Further analysis showed that, as predicted, validity effects were insignificant at short SOA conditions, $F(1, 27) = 1.06$, $P = 0.31$, but significant at long SOA conditions, $F(1, 27) = 4.48$, $P < 0.05$. Contrary to the zooming efficiency hypothesis, the long SOA validity effects were larger for high-CFQ Ss than for low-CFQ S, $F(1, 27) = 8.63$, $P < 0.01$, $r = 0.49$. An ANOVA on the far cue data, with SOA (short/long), validity (valid/invalid) and CFQ (varied continuously between Ss) as independent factors revealed no significant main effects or interactions, F's < 1. These null findings were predicted.

There were very few errors and an ANOVA performed on the error data which included SOA, validity, cue (near/far) and CFQ as independent factors revealed no significant main effects or interactions.

To estimate the costs and benefits associated with zooming we used the mean RT for the far-cue conditions as a baseline. We found nearly significant costs, $F(1, 27) = 3.75$, $P = 0.062$, which were significantly related to CFQ, $F(1, 27) = 6.73$, $P < 0.05$, $r = 0.45$. High-CFQ Ss suffered more costs

than low-CFQ Ss. However, the benefits were insignificant ($F < 1$), and were not significantly related to CFQ, $F(1, 27) = 2.15$, $P = 0.15$, $r = 0.27$).

To determine the relationships between CFQ, zooming, and zooming benefits we computed two scores for each S: CB and validity. CB was defined as the difference between costs and benefits. Positive CB values indicate greater costs than benefits. Validity was computed as the invalid minus valid difference with near cues and long SOA (the only condition which allowed for zooming). Large validity indicates attentional zooming. In addition to the simple correlations we also computed partial correlations of every two variables holding the third variable constant. CFQ correlated significantly with validity ($r = 0.49$, partial $r = 0.42$, P's < 0.05) and validity correlated significantly with CB ($r = 0.56$, partial $r = 0.50$, P's < 0.05). However, CFQ did not correlate significantly with CB ($r = 0.28$, partial $r = 0.01$, N.S.). Hence, high-CFQ Ss focused more than low-CFQ Ss, and Ss who focused their attention in response to the cues suffered more costs than gained benefits.

In the present experiment zooming led to costs and not to benefits. Hence, the most efficient strategy under these conditions was to ignore the cues. We suggest that high-CFQ Ss responded to the cues more than low-CFQ Ss because the former Ss failed to ignore the cues. Jonidas (1981) showed that cues, presented in the periphery, are difficult to ignore. He suggested a distinction between peripheral cues, acting automatically, and central cues, which signal a controlled, effort-demanding shifting of visual attention. The present experiment used peripheral cues which the Ss would have been better to have ignored. Possibly, high-CFQ Ss experienced greater difficulty ignoring the inefficient peripheral cues compared to low-CFQ Ss.

GENERAL DISCUSSION

In our experiments, CFQ was unrelated to intelligence, perceptual-speed or the speed of shifting between action schemas. Furthermore, contrary to our predictions high-CFQ Ss zoomed their covert attention as a response to spatial cues to a greater extent than low-CFQ Ss. However, there were two aspects of the results which suggested a correlation between *some* attentional mechanisms and self-reported cognitive failures: Experiment 2 showed that high-CFQ Ss performed more poorly than low-CFQ Ss on focused attention tasks. All the three tasks required Ss to maintain their focus and ignore distraction by accompanying irrelevant information. Furthermore, the results of Experiment 3 were interpreted as indicating that high-CFQ Ss were more distractible by the inefficient cues than low-CFQ Ss.

We suggested two hypotheses regarding the underlying attentional mechanisms underlying the everyday cognitive failures reported on the CFQ: the first hypothesis suggested that high-CFQ Ss, who report experiencing frequent cognitive failures activate their action schemas less efficiently than low-CFQ Ss. This hypothesis was not supported by the results of Experiment 2. The experiment showed no significant correlation between schema activation efficiency (indexed by shift time) and CFQ. However, the results of Experiment 2 fit our second hypothesis better. According to that hypothesis, high-CFQ Ss are likely to be distracted by irrelevant information. Broadbent *et al.* (1986, 1989), and Smith (1991) found that high-CFQ Ss gained less from knowledge of target location as compared to low-CFQ Ss (the SPUL effect). Broadbent *et al.* (1986) interpreted SPUL as reflecting "the tendency to do well at a search task compared with performance at a focused attention task" (Broadbent *et al.*, 1986, p. 297). This interpretation of the SPUL effect agrees with our conclusions regarding high-CFQ Ss' relative deficiency on focused attention tasks (Experiment 2). One possible reason for this deficiency is that, especially for high-CFQ Ss, peripheral cues cause the automatic zooming of attention. This tendency is helpful on search tasks, but detrimental on focused attention tasks.

It is hard to tell if automatic attentional shifts are the reason for everyday cognitive failures or just another part of the syndrome. It is known that attention shifts that result from peripheral cues are highly automatic (Jonidas, 1981). It may be claimed that high-CFQ Ss' deficiency in ignoring peripheral cues constitutes just another example of faulty triggering of highly automated actions. A major *kind* of everyday cognitive failures (Reason, 1984).

As noted in the introduction, the CFQ questions refer to "loss of activation", "false triggering of action schemas", "failure to trigger action schemas", and "unintentional activation of schemas". High

CFQ *S*s are likely to be distracted. Distraction causes faulty and unintended activation of action schemas. Furthermore, distraction also causes *S*s to lose activation from their intended schemas.

One important qualification of the conclusions drawn so far refers to the relative spatial position of the targets and the distractors. If targets and distractors occupy the same location the correlations between focused attention performance and CFQ are low and usually insignificant. This was shown in the Stroop Colour–Word test and the Embedded Figures test (Martin, 1983), but also in the Colour task used in Experiment 2. However, when the target and the distractor occupy different spatial locations higher correlations between focused attention performance and CFQ are observed [Broadbent *et al.* (1986) and Tipper & Baylis (1987) as well as the Global/Local, the Category-Generation in Experiment 2 and in Experiment 3]. It should be noted that the role of the spatial arrangement of the target and the distractor was not formally tested in this project. Hence, this role should be examined in future research.

Using Norman and Shallice's (1986) model we can return to the question regarding the relationship of attention to self reported cognitive failures. We suggest two distinct levels for this relationship: failure probability and report probability. We suggest that failure probability reflects distractibility. Possibly, the higher distractibility of high compared to low CFQ *S*s is restricted to tasks in which the irrelevant information is spatially separated from the target information. Regarding report probability, Norman (1980) explicitly noted that *S*s identify their cognitive failures only when they recognize a mismatch between their intentions and actions. Therefore, *S*s do not usually regard their planning, problem-solving, and decision errors as cognitive failures. This perspective makes it clearer why objectively defined errors, as measured by intelligence and laboratory memory tests are weakly related to CFQ (e.g. Broadbent *et al.*, 1982). Furthermore, Norman's account also predicts that *S*s who attend to their own intentions and actions are more likely to identify cognitive failures than those who do not. Accordingly, Houston (1989) have recently found a positive correlation between private (but not public) self-awareness and CFQ.

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