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The Cognitive Failures Questionnaire 2.0

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ABSTRACT

Individual differences in the subjective experience of cognitive failures predict important outcomes, such as accident risk. Over the last four decades, these have been measured via the Cognitive Failures Questionnaire (CFQ). However, multiple CFQ items have diminished contemporary relevance and technology-related failures are not represented at all. Further, various attempts to identify multicomponent structures have had problems, which could be due to small numbers of items from which these structures are devised. Here we developed a large set of new items to more fully sample underlying psychological processes, including contemporary instances of cognitive failures, and performed an exploratory factor analysis (EFA) in a sample of adults (Study 1). This identified one dominant factor, which was supported by a subsequent confirmatory factor analysis (CFA) in Study 2. Study 3 replicated the CFA and demonstrated that scores explained variance in objective performance on an attentional control task beyond that explained by the original CFQ. Study 4 demonstrated that scores were associated with focusing, switching, cognitive empathy, affective empathy, and negative affect in ways consistent with the original CFQ. In Study 5, scores demonstrated good test-retest reliability. We offer this 15-item scale as a new and improved measure of cognitive failures (CFQ 2.0).

1. Introduction

To err is human: we all make mistakes in everyday life. Sometimes such everyday cognitive slips and lapses have relatively trivial consequences, such as the inconvenience of missing a forgotten-about appointment. But other times, such cognitive failures can have profound consequences, such as failing to notice a safety-critical road sign resulting in a car crash. While everyone succumbs to cognitive failures, there are clear and meaningful individual differences in the frequency with which they are experienced. One measure that has a long and illustrious history of measuring these differences is the Cognitive Failures Questionnaire (CFQ), first introduced by Broadbent and colleagues more than 40 years ago (Broadbent et al., 1982). The original paper introducing the CFQ has attracted (at the time of writing) over 3000 citations, demonstrating the interest in and impact of measuring these cognitive failures.

The original CFQ consists of 25 items that asks respondents to indicate the frequency with which they have experienced particular cognitive failures in the past six months. Example items include: “Do you find you forget why you went from one part of the house to the other?”, “Do you read something and find you haven't been thinking about it and must read it again?”, and “Do you fail to notice signposts on the road?”. A higher score indicates greater frequency of cognitive failures. Despite being a subjective self-report measure, there is an array of impressive evidence from objective measures to support the validity of CFQ scores. For example, scores are associated real-world consequences of cognitive failures, such as a person's risk of car or work accident (Simpson et al., 2005; Wallace & Vodanovich, 2003), and their risk of hospitalisation following accidents (Larson et al., 1997). CFQ scores have also been found to explain variance in objective performance, such as errors on the Sustained Attention to Response Task (SART) (Linden et al., 2005; Manly et al., 1999; Robertson et al., 1997), Stroop interference (Friedman & Miyake, 2004), and flanker interference under low perceptual load (Forster & Lavie, 2007). They are also related to brain activity, as measured by functional magnetic resonance imaging (fMRI) during cognitive tasks (Garavan et al., 2006; Hester et al., 2004). CFQ scores are also associated with structural differences in brain areas associated with cognitive control between different individuals (Deprez et al., 2011). These findings are consistent with the validity of the subjective self-reports made in the CFQ, because they demonstrate links with relevant objective performance and physiological metrics.

Further, the CFQ appears to capture important and meaningful variance about a person's psychological functioning, because higher scorers are related to increased negative affect such as depression,

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anxiety, and stress (Bridger et al., 2013; Castellon et al., 2004; MacQueen et al., 2003; Robins et al., 2012; Simpson et al., 2005), whereas lower scorers enjoy increased resilience (Lamond et al., 2008), life satisfaction (Haslam et al., 2008), and successful ageing (Jeste et al., 2013). Given this, it is not surprising that the CFQ is widely used in both experimental and applied work as a measure of a person's subjective experience of cognitive failures. For example, CFQ is used as a measure of cognitive function in participants with brain injury (Levine et al., 2011; Robertson et al., 1997) or illness (de Graaf et al., 2021; Elharram et al., 2018; Miskowiak et al., 2021), and to track changes over time following treatment (Campbell et al., 2020; Deprez et al., 2012; Gehring et al., 2009; van den Boogaard et al., 2012) or training (Boyd et al., 2022; Brehmer et al., 2012).

Overall, the CFQ has widespread utility. However, here our motivation for considering a potential update to the CFQ was two-fold. First, the CFQ is more than 40 years old. The role of modern technology in everyday life has vastly changed in the intervening four decades, and therefore not all items have the same relevance that they did at the time of development, and there are new types of everyday cognitive failures that are currently missing from the CFQ. For example, some of the CFQ items refer to objects that feature far less commonly in everyday life compared with when the CFQ was developed (e.g., physical newspapers) and none of the original CFQ items refer to cognitive failures that commonly emerge in relation to technology use (e.g., forgetting passwords). Recent work highlights that smartphone use impacts cognitive function in both positive and negative ways (Hartanto et al., 2023), and therefore a measure of everyday attentional control that does not consider the role of technology may not be fully sampling the instances of potential cognitive failures that people make in everyday life. While there is strong evidence for the validity of the CFQ, it is possible that the CFQ's validity may be declining over time due to these issues. In other words, it may be time to revisit and update the CFQ to see if we can enhance its validity. Second, another aim was to test whether we could identify a stable multifactor structure, or whether the CFQ is indeed best conceptualised as unitary. We explain the rationale for this below.

When Broadbent and colleagues first introduced the CFQ, they noted that it consisted of errors across the domains of perception, memory, and action. But they reported that despite their multiple attempts to find a stable multicomponent factor structure, they were unable to do so. They therefore emphasized that the CFQ was best represented via a unitary factor (Broadbent et al., 1982). However, the notion that the CFQ may have a multifactorial structure has remained an appealing one, because since its introduction to the literature, there have been multiple attempts to identify such a structure (e.g., Larson et al., 1997; Pollina et al., 1992; Tirre, 2018; Wallace et al., 2002; Wilhelm et al., 2010). However, there is no consensus on an underlying multifactorial structure, and different attempts to identify it been plagued with issues of interpretability, such as factor structures in which: (a) items load on more than one factor (Rast et al., 2009), (b) there is a prohibitively small number of items per factor (Matthews et al., 1990), (c) different factors appear to measure the same construct (e.g., Larson et al., 1997), and/or (d) structures being unstable despite initial promise (e.g., Bridger et al., 2013). Most of the proposed multicomponent factor structures have never been shown to explain more variance in relevant constructs (e.g., cognitive performance) than their unitary counterpart. Often this is because the unitary and multifactorial models are never directly pitted against one another, but when they have been, they have not offered any additional utility over the unitary model (Goodhew & Edwards, 2023).

We reasoned that one possible explanation for at least some of these issues with the obtained multicomponent factor structures is that they are typically derived only from the original 25 CFQ items. That is, only the original CFQ items are subjected to factor analysis to identify the potential multifactorial structure. It could be that there is a meaningful multicomponent factor structure to the CFQ, but more items for potential factors are required to elucidate it than is available in the original CFQ. In other words, more candidate items may need to feature in an exploratory factor analysis for meaningful components to be revealed. For example, there is one item in the original CFQ that appears to reflect an instance of an emotion-regulation failure: “Do you lose your temper and regret it?”. If emotion regulation is one of the component factors of a multifactorial CFQ structure, and this is the only item that is strongly representative of this aspect that is included in an exploratory factor analysis, then this could make it difficult to identify a stable structure that includes an emotion regulation factor, in the absence of additional items that also reflect emotion regulation failures. Therefore, we identified the candidate psychological processes underlying the original CFQ, and from this developed a broader range of items designed to gauge these processes, including ones with contemporary relevance. This allowed us to test whether a stable multifactor structure emerged under these conditions.

2. Study 1

The goal of Study 1 was to develop a larger pool of items with which to assess subjective cognitive failures, including those that gauge more contemporary everyday cognitive failures, and to determine the factor structure underlying subjective cognitive failures via an exploratory factor analysis. To this end, we identified the putative psychological processes underlying the original CFQ items, and then developed a larger set of candidate items designed to gauge these processes. We then submitted responses to these items from a large sample of participants to an exploratory factor analysis.

2.1. Method

2.1.1. Raw data

De-identified data for all studies are publicly available via OSF: hhttps://osf.io/ak5um/. (Reverse-scoring already applied to numeric values for responses in these files).

2.1.2. Participants

Tabachnick and Fidell (2013) recommend a minimum sample size of 100–200 for a good factor analytic model with clear factors and high communalities, or 300 if these values are more intermediate. Therefore, we sought to have a minimum sample size of 300. A total of N = 323 United Kingdom (UK)-based participants were recruited via Prolific (https://www.prolific.co). All participants in this and subsequent studies reported here provided informed consent prior to participation. This research was approved by the University's Science and Medical Delegated Ethics Review Committee (protocol 2022/029). To save space, participant demographics for this and subsequent studies are reported in the Supplementary Material.

2.1.3. Materials

Two cognitive psychologists (the authors) considered the types of psychological processes that could be underlying the cognitive failures identified in original CFQ items, and created new items designed to assess a similar construct. In doing so, an additional aim was to sample more modern instances of cognitive failures. We explain these hypothesised processes in the sections below. Of course, the items created may reflect more than one of the psychological processes identified (or even a different one to that intended). It is the nature of real-world cognitive failures that they are unlikely to reflect exclusively one cognitive process. Instead, the hypothesised psychological processes were used as guidelines for developing new potential CFQ items – the factor analysis will ultimately reveal the latent structure underlying these items. The full list of 64 new items is available in the Supplementary Material.

Multiple original CFQ items are about a failure to complete actions, such as leaving important letters unanswered for days, forgetting what you came to the shops to buy, or why you went from one part of the house to another. There are multiple possible psychological processes that could be implicated in such failures. These include (1) a failure to encode and/or recall important information as needed (e.g., not encoding/recalling one's shopping list), (2) a failure to remember to complete a planned action or intention at a particular point in time or in response to an event, that is, a failure in *prospective* memory (e.g., forgetting one's plan to respond to a letter when you get home from work), (3) a failure to self-impose organisation and prioritisation, even if the information is correctly recalled (e.g., knowing should respond to a letter but doing something else instead). Therefore, we developed new items designed to gauge each of these processes, including more contemporary instances of them. With respect to failures of memory encoding and/or memory recall, we developed items such as "Do you forget passwords you need to remember?" and "Do you receive a delivery and forget what you ordered?". For failures of prospective memory, items included "Do you forget to pass on messages?", "Do you forget to attach documents you intended to send in an email?", and "Do you forget to take your keys with you?". Further, we developed items designed to gauge organisation and prioritisation, such as, "Do you put off doing important tasks?", and "Do other people say you are organised?"

Many of the original CFQ items can be considered under the umbrella of inattentiveness, including focusing on internal thoughts to the detriment of processing external stimuli (e.g., reading something and finding you haven't been thinking about it and must read it again and daydreaming when you ought to be listening to something). Therefore, we developed new items in a similar vein, such as, "Do you find yourself losing concentration on a task?", and "Do you accidentally select the wrong item when ordering something online?". We also included items that gauged organisation of things in physical and virtual space, as this could be another manifestation of attentional control and organisation more broadly, such as, "When packing a suitcase, do you neatly fold items?", and "Do you keep your computer files in well-labelled folders?".

We also reasoned that several items reflect errors in the execution of behavioural sequences, such as forgetting why you went from one part of the house to another, and a failure to process relevant information from the environment when executing such behavioural sequences (e.g., bumping into people, failing to notice signposts on the road). Therefore, some new items were "Do you find you go to put objects in the wrong place, like putting something from the cupboard in the fridge?", and "Do you pick up the wrong thing (e.g., fork instead of a knife)?"

Further, some of the original CFQ items appeared to reflect issues in social communication and action, such as saying something and realising later it might be taken as insulting and being unable to think of something to say. Therefore, we created new items designed to gauge such issues, including mistakes in the giving and receiving of such communications, such as, "Do you say out loud something you meant to keep to yourself?", and "Do you misunderstand what people mean?"

In addition, we developed multiple items to gauge processes that appeared to be predominately related to only one of the original CFQ items. For example, one of the original CFQ items was about losing your temper and regretting it. We therefore developed new items designed to gauge the experience of intense emotions and emotion regulation failures, such as, "Do you often feel overwhelmed by your emotions?", and "Do you think negative thoughts or recall negative memories?". We also included items around failures to control maladaptive emotion regulation behaviours, such as "Do you eat unhealthy food and later regret it?". Another one of the original items was about difficulty making up one's mind, and therefore we included multiple items about decisiveness, such as, "Do you have trouble deciding what to do when meeting up with friends?". Another original item was about failing to see something in the supermarket even though it was there, so we had new items such as "Do you think something is missing, only to later see it where you had already looked?"

The 64 new items plus the original 25 CFQ items were included in the factor analysis. We modified one word in two of these original items to make them more appropriate for a contemporary audience (i.e., letters > emails, and newspaper > phone). Participants rated the extent to which they had experienced these cognitive failures in the previous six months on a five-point rating scale: Never, Very Rarely, Occasionally, Quite Often, Very Often, scored from 0 (Never) to 4 (Very Often), except for eight reverse-scored items which were scored from 4 (Never) to 0 (Very Often). To identify spurious or inattentive responses, two Attention Checks were included, which asked participants to respond "Never" and "Quite Often". Further, as another data-quality check, participants were asked their year of birth early in the study, and later their age (along with their gender, country of birth, native language, and their dominant hand).

2.1.4. Procedure

Participants were first shown the Information Sheet, and then asked to select one of two responses, either: "Yes, I consent to participate in this research" or "No, I do not continue to participate in this research". If they selected the latter, they did not continue to the study. Participants were asked their year of birth. Next, they received the instructions (see Appendix B) and then completed the CFQ items (original + new) and attention check items in an order randomised for each participant. Finally, they were asked demographic questions, and then provided with debriefing.

The study was run online via Qualtrics. With the exception of consent (for which a response was mandated before progression), missed item responses triggered a prompt reminding them to answer the missed questions, but they were not forced to (i.e., could continue without answering). This was true for all subsequent studies, except Study 3 run via Testable which does not offer this feature (so for that study there was no reminder for missed responses, but participants could not progress without indicating consent).

2.2. Results

Two participants' data was excluded from further analysis for a mismatch between their reported age and year of birth, while a further two were excluded due to failure to respond as requested to the attention checks, leaving a final sample of N = 319. There was no missing data. Statistical analysis was performed in JASP Version 0.14.1 (JASP Team, 2020).

Responses were submitted to an exploratory factor analysis (EFA). The method for determining the number of factors was a parallel analysis using the minimum residual estimation method and an oblique oblimin factor rotation based on the covariance matrix. Bartlett's test was significant ($p < .001$), and root mean square error of approximation (RMSEA) = 0.043. The EFA yielded five factors, which explained 15 %, 12.5 %, 6.6 %, 4.6 % and 3 % of the variance in the original responses respectively. However, only the first three factors were clearly interpretable and had sufficient items with factor loadings 0.5+. (While lower factor loading cut-offs are sometimes used, we chose to enforce a 0.5+ criterion to help improve the selectivity of the factors if multiple factors were to emerge to minimise any potential item sharing between factors, e.g., Rast et al., 2009). The scree plot (see Fig. 1) indicated that there was a dominant first factor, and no utility beyond the first three factors. These three factors and the item factor loadings that meet or exceed 0.5 are provided in Appendix A (see Supplementary Material for high factor loadings for all factors), and correlations among the factors are shown in Table 1.

Factor 1 consisted of 15 items, 6 from the original CFQ and 11 of the new items developed for this project. This factor appears to reflect inattentiveness (e.g., Do you fail to hear people speaking to you when you are doing something else?), forgetfulness (e.g., Do you leave home and later realise you have forgotten something you intended to bring with you?), and the failure to maintain goal or action sequences (e.g., Do you find you go to put objects in the wrong place, like putting something from the cupboard in the fridge?). This is similar to the scope of the original CFQ (Rast et al., 2009; Thomson & Goodhew, 2021). The main differences appear to be that: (a) that some of the original CFQ items

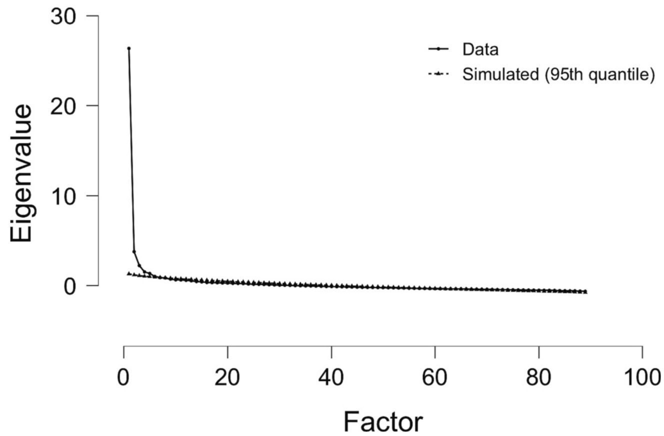

Fig. 1. A scree plot of the EFA in Study 1.

Table 1
Factor correlations from the EFA in Study 1.

	Factor 2	Factor 3
Factor 1	0.469	0.375
Factor 2		0.395

(including those about letters and newspapers) did not load on any factors, and (b) the items linked to negative emotions and indecision that are present the original CFQ were not part of Factor 1 but instead loaded onto Factor 2. Factor 2 consisted of 11 items, 2 from the original CFQ and 9 new items. This factor appears to reflect issues with negative emotion (e.g., Do you get upset by things?) and difficulty regulating emotion (e.g., Do you often feel overwhelmed by your emotions?), rumination (e.g., Do you worry about things?), indecision (e.g., Do you have trouble making up your mind?), and difficulty planning or executing behaviours (e.g., Do you put off doing important tasks?). Factor 3 consisted of 5 items, all new, which span organisation and tidiness (e.g., Do other people say that you are organised? [reverse scored]). For shorthand, we name these three factors: Inattentive / Forgetfulness (IF), Emotion Regulation and Planning Failures (ER), and Organisation and Tidiness (OT).

2.3. Discussion

Altogether, the EFA identified one strong factor, and two additional factors. These factors were moderately correlated. The EFA identified these three factors as dissociable but related. There are two possible interpretations for this. On the one hand, cognitive failures could consist of these three components. On the other hand, however, the first factor appears to represent the most classical types of cognitive failures that the CFQ was designed to reflect. The factor analysis may have distinguished these from Factors 2 and 3 because these are distinct constructs that share variance with cognitive failures. For example, the size of the correlation between the first and second factors here is similar in magnitude to that previously observed between CFQ total scores and emotion regulation difficulties ($r = 0.51$) (Robins et al., 2012). Thus, the EFA may have pulled these items out on a separate factor because they represent a distinct but correlated construct, rather than truly another component of cognitive failures. Therefore, based on the results of the EFA, there are two candidate models: (1) a model consisting of only the first factor identified here (CFQ 2.0 1-factor), and a model consisting of the first three factors identified here (CFQ 2.0 3-factor). Study 2 consisted of a Confirmatory Factor Analysis (CFA) of both models.

3. Study 2

The purpose of Study 2 was to conduct a Confirmatory Analysis (CFA) assessing two models: (1) a one-factor model of the first factor identified in Study 1 (CFQ 2.0 1-factor), and (2) a three-factor model consisting of the three factors identified in Study 1 (CFQ 2.0 3-factor).

3.1. Method

3.1.1. Participants

A total of 350 UK-based participants were recruited via Prolific and completed Study 2. Those who participated in Study 1 were prevented from participating.

3.1.2. Materials

The 56 CFQ items consisted of original 25 CFQ items, plus the 31 items from CFQ 2.0 that were identified as loading on three factors identified in the EFA in Study 1. The same two attention check items were also included. The same rating scale was used as Study 1.

3.1.3. Procedure

The study was run online via Qualtrics. After participants provided informed consent, they were asked their year of birth. Next, they were given the same CFQ instructions as Study 1, followed by a block of the 56 CFQ items and attention check items in an order randomised for each participant. Subsequently, they completed the demographics block and were then debriefed.

3.2. Results

Two participants' data was excluded for a mismatch between their reported age and year of birth, and another was excluded due to failure to respond as requested to the attention checks, leaving a final sample of $N = 347$. There was no missing data. The model fit statistics are provided in Table 2. We chose Comparative Fit Index (CFI) and Root Mean Squared Error of Approximation (RMSEA) because these are useful and widely-used fit indices, and consistent with both statistical recommendations and previous factor analytic work on the CFQ, we interpret CFI values >0.90 and RMSEA values <0.08 as indicating adequate model fit (Browne & Cudeck, 1993; Rast et al., 2009; Swan, 2021).

Table 2 shows that only CFQ 2.0 1-factor met both model-fit criteria. CFQ 2.0 1-factor also had good internal consistency (McDonald's ω = 0.87 [0.85–0.89]). Full descriptive statistics are available in the Supplementary Material. We also tested whether the CFQ 2.0 1-factor structure was consistent across participants' age and gender (see supplementary material), and this suggested that model fit remained adequate across these different groups.

3.3. Discussion

The results indicated that the one-factor CFQ 2.0 provided a good fit for the data. The three-factor CFQ 2.0 did not meet required model fit benchmarks, and thus from here the focus was on validating the one-factor CFQ 2.0.

Table 2
Results of CFA in Study 2.

Factor	CFI	RMSEA
CFQ 2.0 1-factor	0.943	0.050 [0.038–0.062]
CFQ 2.0 3-factor	0.863	0.062 [0.057–0.067]

Note. CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation. 90 % confidence intervals of RMSEA shown in square brackets.
Note. The original 25-item CFQ 1.0 did not have adequate model fit indices (CFI = 0.831, RMSEA = 0.066 [0.060–0.072]), further highlighting the need for a revised CFQ.

4. Study 3

The results of Study 2 provided support for the new one-factor CFQ 2.0. Study 3 tested whether scores on this CFQ 2.0 could explain objective performance variance in an important attentional control task. The specific outcome was target hits/misses in low prevalence (or rare target) visual search. Here we explain the rationale for selecting this task.

When targets are rare, they are highly likely to be missed (Wolfe et al., 2005). This has important implications for real-world visual search tasks such as diagnostic medical imaging (e.g., for tumours in a scan) and airport baggage security screening (e.g., for a gun in a suitcase), which are characterised by rare targets and potentially dire consequences for human health when targets are missed. The main driver of the low prevalence performance detriment is *not* target visibility – the same targets are detected easily in high prevalence contexts. Instead, target misses in low prevalence visual search conditions reflect more attentional and cognitive processes such as lapses and difficulty maintaining goal sets in the absence of scaffolding from frequent target-present trials (e.g., it is more difficult to maintain a goal set for 'gun' when most trials do not contain a gun, compared with when many of them do) (e.g., Thomson & Goodhew, 2021). This has considerable conceptual overlap with cognitive failures and the CFQ, where multiple items reflect the failure to maintain goal sets (e.g., losing track of why went from one part of the house to another, or what came to the shops to buy). Consistent with this, CFQ scores have been found to predict variance in rare target visual search performance (Goodhew & Edwards, 2023; Thomson & Goodhew, 2021). Further, low prevalence visual search accuracy is associated working memory capacity (Schwark et al., 2013), consistent with cognitive failure relating to executive functions.

The Sustained Attention to Response Task (SART) was specifically developed to align with the construct of cognitive failures (Robertson et al., 1997). In the SART, participants must withhold a response to a relatively infrequent target while making a response to frequent non-targets. SART is essentially a simple low prevalence visual search task. Errors on this task are thought to reflect types of absent-minded errors that the CFQ reflects (Manly et al., 1999; Robertson et al., 1997). We therefore wanted to choose a validation test task that had infrequent targets. We chose low prevalence visual search over SART as it better reflects real-world tasks that demand attentional control and was likely to produce a greater range in performance.

If CFQ 2.0 scores can explain significant variance in target misses in rare target visual search, then this would be evidence consistent with their validity. We also tested the replicability of the CFA from Study 2.

4.1. Method

4.1.1. Participants

A total of 368 participants were recruited via Testable Minds (https://minds.testable.org/). Participants were required to be verified human Minds in the platform.

4.1.2. Materials

The same CFQ questions, attention check items, and rating scales that were used in Study 2 were used again. We did not include the data quality check comparing reported year of birth with current age in this study, because here participants' objective performance data (coupled with the two attention check items) would suffice for this purpose.

4.1.3. Stimuli

We used the identical stimuli as Experiment 1 in Goodhew and Edwards (2023), where these stimuli provided reliable measurement of rare target misses. That is, there were 400 visual search arrays in the main experiment. Each array contained nine alphanumeric stimuli arranged in a 3 × 3 grid. The characters were black on a white background. The target was the number 7, it was present in 16 out of 400 arrays (i.e., 4 % target prevalence). Nontarget stimuli in each array were selected without replacement from the set: 1, 2, 3, 4, 5, 6, 8, 9, J, L. Another set of eight search arrays were used in the practice block. While participants completed the experiment on their own computer, the arrays were 600 × 600 pixels, which corresponded to approximately 10.5 × 10.5 cm on a Retina 5 K 27-in. iMac following calibration. An example target-present array is shown in Fig. 2.

4.1.4. Procedure

The study was run online via Testable (www.testable.org). The study began with a Captcha, and then Testable's inbuilt calibration, designed to ensure the stimulus size is matched across participants' computers. Next, participants provided informed consent, and then completed the demographic questions. It was randomised across participants whether they next received the CFQ block or the rare target visual search block.

In the CFQ block, participants received the onscreen instructions (same as Study 1 and 2), followed by the CFQ items and two attention check items in an order randomised for each participant.

In the visual search task, onscreen instructions told participants to press the M key if they saw the number 7 in the array, and otherwise to press the Z key. They then completed eight practice trials (2 target-present) with onscreen feedback about the accuracy of each response. Following this, they were reminded of the task instructions before progressing to the main experiment. This consisted of 400 trials, of which only 16 contained a target (4 % target prevalence). Search array trials were randomly intermixed for each participant, with the constraint that the first 16 trials in the block were always target-absent trials. On each trial, the search array was presented until response, followed by an intertrial interval of 800 ms during which the screen was blank.

4.2. Results

Participants' data was excluded from further analysis if: (a) they did not respond as requested to the two attention-check items (7 exclusions), (b) if their accuracy on the target-present trials equalled 0 % which could indicate task disengagement (0 exclusions), (c) if their accuracy on target-absent trials fell below 90 % for the same reason (5 exclusions),

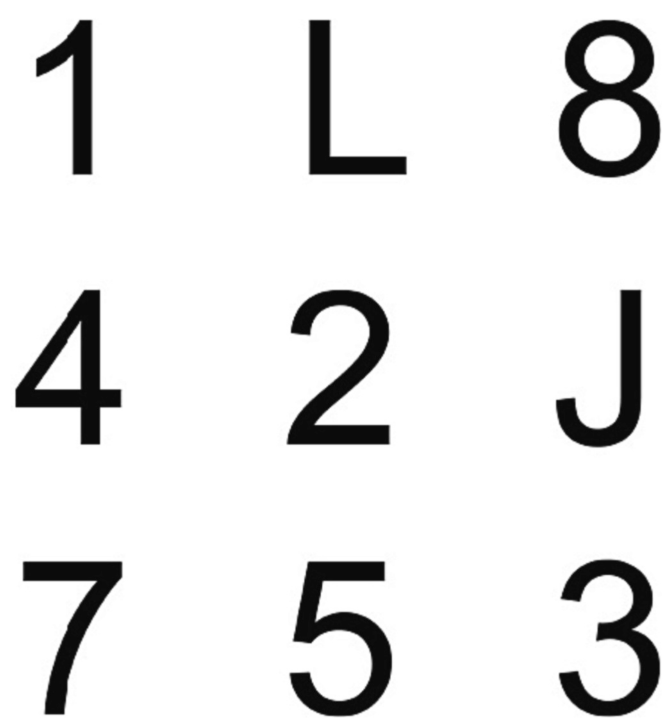

Fig. 2. An example of a target-present array used in Study 3.

and (d) if they had missed responses to any CFQ items (25 exclusions). This left a final sample of N = 331. In relation to (d), to check that missing data did not distort the analysis, we performed an additional analysis where these participants were retained for analysis (total N = 356), and this supported the conclusions from the main analysis (see Supplementary Material). The descriptive statistics and reliability estimates for CFQ 2.0 scores and task performance are provided in the Supplementary Material.

The results of the CFQ in Study 3 are presented in Table 3, along with relationship between CFQ 2.0 scores and target-present accuracy (i.e., hits/misses) in the rare target visual search experiment.

From Table 3 it can be seen CFQ 2.0 scores explained a significant amount of variance in rare-target visual search performance. The replication of the CFA also indicated that the 1-factor CFQ 2.0 model once again had acceptable CFI and RMSEA values.

We also compared how the CFQ 2.0 (1-factor) fared relative to the original CFQ (i.e., CFQ 1.0). First, as per Study 2, the CFA indicated that the CFQ 1.0 did not have good model fit (CFI = 0.872, RMSEA = 0.058). In contrast, the CFQ 2.0 performed better on these indices, as described above. Second, when a hierarchical linear multiple regression was performed predicting target-present accuracy, where CFQ 1.0 scores were included in the first step, CFQ 2.0 scores explained a significant amount of variance above and beyond CFQ 1.0 scores ($R^2_{change} = 0.02$, $p = .010$). This demonstrates incremental validity of the CFQ 2.0 over the CFQ 1.0.

4.3. Discussion

Study 3 replicated the CFA results from Study 2 in showing that the 1-factor CFQ 2.0 model had adequate model fit. Here, these CFQ 2.0 scores also explained significant variance in objective performance in rare-target visual search, and did so over and above that explained by CFQ 1.0. This is evidence consistent with CFQ 2.0 scores gauging meaningful individual differences in attentional control and indicates incremental validity of the CFQ 2.0 over the CFQ 1.0.

5. Study 4

Studies 1–3 indicated strong support for our new 1-factor CFQ 2.0. As an additional test of the validity of this new measure, we sought to assess whether scores from it were associated with related constructs in the ways consistent with what has been observed for subjective cognitive failures in previous research. In particular, higher cognitive failures have been found to be associated with: increased difficulty in focusing and shifting components of subjective attentional control (Judah et al., 2014), reduced cognitive empathy (i.e., taking others' perspective to understand their thoughts and feelings), but increased affective empathy (i.e., feeling others' emotions) (Goodhew & Edwards, 2022), and increased negative affect (Simpson et al., 2005). Here, therefore, we measured focusing, shifting, cognitive empathy, affective empathy, and negative affect, in addition to CFQ 2.0 1-factor scores, and examined their associations. First, however, we describe the background for the relationship between cognitive failures and each of these variables.

Table 3
Results of CFA and correlation with rare target performance in Study 3.

Factor	CFI	RMSEA	Spearman's rho correlation with accuracy
CFQ 2.0 1-factor	0.929	0.058 [0.046–0.069]	−0.12* [−0.22, −0.01]

Note. CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation. 90 % confidence intervals of RMSEA shown in square brackets. *Note.* * = $p < .05$.
Note. As per Study 2, the Study 3 CFA also indicated that fit indices for the 3-factor CFQ 2.0 model were inadequate (CFI = 0.864, RMSEA = 0.057 [0.052, 0.063]). This further supports the focus on the 1-factor CFQ 2.0.

The Attentional Control Scale (ACS) consists of two distinct components, Focusing and Shifting (Judah et al., 2014). Focusing is the capacity to concentrate on goal-relevant information without succumbing to distraction, while Shifting is the capacity to efficiently switch between different tasks or goals. Focusing has been found to be associated with the ability to inhibit prepotent responses, as operationalised by the anti-saccade task, while Shifting has been found to be associated with task-switching performance (Judah et al., 2014). Focusing and Shifting (where higher scores indicate greater attentional control) have been found to be negatively correlated with CFQ scores (Goodhew & Edwards, 2024).

Cognitive empathy (also theory of mind, mentalising, or perspective-taking) is about taking another's perspective to understand their mental states (akin to 'putting yourself in someone else's shoes). This is thought to require domain-general attentional control such as the ability to inhibit one's own dominant perspective and to shift attention between different perspectives (Apperly et al., 2009; Goodhew & Edwards, 2022). Consistent with this, impairing domain-general attentional control via a concurrent load impairs reasoning about others' mental states (McKinnon & Moscovitch, 2007), and individual differences in cognitive empathy are related to individual differences in attentional control (Goodhew & Edwards, 2021, 2022). In contrast, affective empathy (feeling what others are feeling) appears to be negatively correlated with attentional control (Goodhew & Edwards, 2021, 2022). Here, therefore CFQ 2.0 scores should be positively correlated with cognitive empathy and negatively correlated with affective empathy.

Susceptibility to experience negative affect (including depression, anxiety, and stress) is associated with poorer attentional control, as gauged both by objective performance indices (Shi et al., 2019) and CFQ scores (Bridger et al., 2013; Goodhew & Edwards, 2022, 2024; MacQueen et al., 2003; Simpson et al., 2005). This may be because processes such as rumination consume attentional resources thereby impairing task-related attentional control, or reduced intrinsic attentional control abilities may make an individual susceptible to negative affect (e.g., via reduced use of effective but cognitively-demanding emotion regulation strategies). Here, therefore, CFQ 2.0 scores should be positively correlated with negative affect.

5.1. Method

5.1.1. Participants

Here we sought to have sufficient power to replicate the correlation between original CFQ scores and cognitive and affective empathy observed in previous research (Goodhew & Edwards, 2022). The smaller of the two correlations was between CFQ and cognitive empathy, r_s (392) = −0.20. G*Power indicated that to replicate this with 80 % power in the point biserial correlation function, N = 191 was required. To facilitate meeting this even with potential exclusions, 10 % was added, and therefore we sought to recruit N = 200. Participants were N = 200 recruited from the University's SONA participant pool.

5.1.2. Materials

Participants completed the 15 items comprising the 1-factor CFQ 2.0. Participants also completed the Focusing and Shifting items of the Attentional Control Scale (ACS) identified in Judah et al.'s (2014) factor analysis, the Questionnaire of Cognitive and Affective Empathy (QCAE) to measure Cognitive and Affective and Empathy, and the Depression Anxiety and Stress Scale (DASS) to measure Negative Affect. More details on each these measures are provided below.

Judah et al.'s (2014) factor structure of the ACS (Derryberry & Reed, 2002) consists of 7 Focusing items (e.g., "It's very hard for me to concentrate on a difficult task when there are noises around") and 5 Shifting items (e.g., "I can quickly shift from one task to another), where respondents indicate their level of agreement on a four-point scale (1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Always). All the Focusing items are reverse-scored, such that higher scores indicate greater attentional control. Focusing and Shifting have differential relationships with objective measures of attentional control (Judah et al., 2014).

The Questionnaire of Cognitive and Affective Empathy (Reniers et al., 2011) consists of 19 Cognitive Empathy items (e.g., "I try to look at everybody's side of a disagreement before I make a decision") and 12 Affective Empathy items (e.g., "I often get emotionally involved with my friends' problems"). Respondents indicate their level of agreement on a four-point scale (1 = Strongly Disagree, 2 = Slightly Disagree, 3 = Slightly Agree, 4 = Strongly Agree). Three Affective Empathy items and one Cognitive Empathy item are reverse-scored, such that higher scores indicate greater empathy. QCAE scores are associated with psychopathy, aggression, and moral reasoning (Reniers et al., 2011), and the cognitive and affective components are differentially associated with individual differences in brain structure in areas implicated in the different components of empathy (Eres et al., 2015).

The 21-item Depression Anxiety and Stress Scales (DASS-21) (Lovibond & Lovibond, 1995) consists of 21 items that span Depression, Anxiety, and Stress, and total score is a valid measure of negative affect (Henry & Crawford, 2005). The DASS-21 consists of statements such as, "I found it hard to wind down" and participants respond via a four-point scale (0 = Never, 1 = Sometimes, 2 = Often, 3 = Almost Always) based on their experiences in the past week. Higher scores indicate greater negative affect. Scores are summed and then multiplied by two (to make them comparable to DASS-42 scores).

5.1.3. Procedure

Participants gave informed consent and then completed the CFQ block, QCAE block, ACS block, and DASS block in an order randomised for each participant. Within each of these blocks, the order of items corresponded to the standard order of items for that measure (For CFQ 2.0, this means the order that they appear for factor 1 in Appendix A and B). Two attention check items were included.

5.2. Results

A total of 200 participants consented and completed the study. Of these, 12 failed to respond to the attention-check items as requested, and their data was excluded from further analysis. Therefore, the final sample consisted of N = 188. Descriptive statistics are provided in the Supplementary Material. A square-root transformation was applied to Negative Affect (i.e., DASS-21) scores which successfully addressed their positive skew. The Pearson's correlations between the variables are shown in Table 4.

Table 4 shows that the variables were related with one another in ways consistent with previous research, such as a positive correlation between Shifting and Cognitive Empathy and a negative correlation between Focusing and Affective Empathy (Goodhew & Edwards, 2021). This shows that even though after exclusions the final sample size slightly below that suggested by the power analysis (N = 189 versus N = 191), there was evidence that this study was sufficiently powered to detect intended relationships. Crucially, Table 4 shows that CFQ 2.0 scores were correlated with the other variables measured as expected. That is, increased Cognitive Failures were associated with reduced Focusing and Shifting and Cognitive Empathy, and increased Affective Empathy and Negative Affect.

Table 4
Pearson's correlations between CFQ 2.0 scores and variables of interest in Study 4.

Variable	CFQ 2.0	Focusing	Shifting	Cognitive empathy	Affective empathy
Focusing	−0.55*** [−0.65, −0.45]				
Shifting	−0.35*** [−0.47, −0.21]	0.40*** [0.27, 0.52]			
Cognitive Empathy	−0.16* [−0.30, −0.02]	0.13 [−0.02, 0.26]	0.33*** [0.20, 0.45]		
Affective Empathy	0.26*** [0.13, 0.39]	−0.34*** [−0.46, −0.20]	−0.17* [−0.31, −0.03]	0.27*** [0.13, 0.40]	
Negative Affect	0.47*** [0.35, 0.58]	−0.54*** [−0.63, −0.43]	−0.35*** [−0.47, −0.21]	−0.12 [−0.26, 0.03]	0.31*** [0.18, 0.44]

Note. * = $p < .05$. ** = $p < .01$, *** = $p < .001$.

5.3. Discussion

Study 4 yielded evidence consistent with the validity of CFQ 2.0 scores. That is, CFQ 2.0 scores were positively correlated with negative affect and affective empathy, and negatively correlated with focusing, shifting, and cognitive empathy.

6. Study 5

It has been found that the test-retest reliability of a personality scale is a stronger predictor of validity than its internal consistency (McCrae et al., 2011). Here, therefore, we measured the CFQ 2.0's test-retest reliability over a period of 7–8 days.

6.1. Method

6.1.1. Participants

G*power indicated that to have 80 % power to detect a medium effect size in a point biserial correlation function required N = 82. We were unsure what the attrition rate from a multipart study would be, so we recruited N = 165 at Time 1 via Prolific, and 7–8 days later 135 of these participants completed Time 2. Participants were required to be over 18, residing in the UK or Australia, and have at least 10 previous Prolific submissions and at least 90 % approval rating (to increase the probability of retention).

6.1.2. Materials & procedure

Via Qualtrics, participants were presented with 15 items of the CFQ 2.0, followed by demographic and data-validity questions (Yes/No answers required to 'I am personal friends with the King of England', 'I have been to the moon', and 'I have used a computer before') and their Prolific ID number.

6.2. Results

N = 131 participants completed both Time 1 and 2 and provided IDs that could be linked between the two sessions. Of these, four were excluded because the country of birth they reported changed between Time 1 and Time 2, and one for their reported age decreasing from Time 1 to Time 2, leaving N = 126. All of the data validity questions were answered in the expected way (No, No, Yes) at both time points, and there were no missing scale responses. Following this, the correlation between CFQ scores at Time 1 and Time 2 was strong: r (124) = 0.88, $p < .001$, [0.83, 0.91]. While there was some skew to CFQ 2.0 scores, the non-parametric Spearman's rho correlation was similar, r_s (124) = 0.88, $p < .001$, [0.84, 0.92].

6.3. Discussion

Test-retest reliability scores between 0.8 and above are considered good (Cicchetti, 1994). Here, therefore, the CFQ 2.0 demonstrated good test-retest reliability.

7. General discussion

Subjective cognitive failures, as measured via the CFQ, have a long and illustrious history of being an important and impactful aspect of both experimental and applied work. Here we sought to modernise the items in the CFQ to see if this would enhance its validity, and to assess whether there was a reliable multifactor structure when a larger pool of items was used in scale development. The EFA in Study 1 supported a dominant 1-factor consisting of 15 high-loading items. The CFA results obtained in Study 2, and subsequently replicated in Study 3, indicated adequate model fit for this model. Study 3 also showed that individuals' scores on this new scale explained significant variance in rare-target visual search, which is consistent with the CFQ 2.0 gauging lapses in attentional control. Here, CFQ 2.0 outperformed CFQ 1.0 in being able to explain variance in objective performance on this important task. Study 4 demonstrated scores were associated with other processes including focusing, shifting, cognitive empathy, affective empathy, and negative affect, in ways consistent with the original CFQ. Study 5 showed that CFQ 2.0 scores had good test-retest reliability. We propose that this new measure be considered a CFQ 2.0. The CFQ 2.0 has several advantages, such as: (a) it includes cognitive failures relevant to contemporary life and removes those no longer relevant, (b) it is shorter than the original CFQ (15 items vs 25 items), reducing time demands on patients and participants, and crucially (c) it has incremental validity over the CFQ 1.0 in explaining objective performance in an important attentional control task. We anticipate that this will prove a useful experimental and clinical tool.

Our results did not support the notion that there is a multifactorial structure underlying the CFQ. Although we designed this project to maximise the opportunity to obtain a viable multifactorial structure, the results repeatedly supported the single-factor model. While various multifactorial structures have been proposed in the literature (e.g., Rast et al., 2009; Wilhelm et al., 2010), single-factor models are the most parsimonious, and thus distinguishing multiple factors is only warranted if this approach improves the measure's capacity to explain variance in important and relevant constructs. To our knowledge, no multifactorial CFQ structure has been demonstrated to do what our 1-factor CFQ 2.0 was able to do here: explain variance above and beyond that already accounted for when controlling for CFQ 1.0. Our results converge with Broadbent and colleagues' suggestion that the CFQ is best treated as a unitary factor.

There does appear to be evidence of multifaceted structures in *objective* cognitive performance on laboratory tasks (Miyake & Friedman, 2012). However, the present results suggest that when it comes to one's subjective experiences of cognitive failures in everyday life, these distil down to a unitary factor. These are not necessarily contradictory, because a given subjective cognitive failures may arise from multiple distinct cognitive processes. For example, in not being able to state someone's name, laboratory tasks may be able to distinguish a failure of initial *encoding* (e.g., due to insufficient attention paid at the time of learning someone's name) from a failure of *retrieval* of encoded information. However, the real-world subjective experience of both failures may be fundamentally similar – the awkwardness of not being able to generate someone's name in a conversation. Thus, while encoding and retrieval are dissociable processes, they both result in the same subjective experience, and therefore a measure of subjective experiences like the CFQ will not differentiate between them.

7.1. Constraints on generality

It is promising that the validity of the CFQ 2.0 generalised across different samples, such as the CFA obtained with a UK-based sample (Study 2) replicating in a more diverse international sample (Study 3). However, it is also important to acknowledge that all participants in all the present studies participated online. Given that a number of items relate to technology-related experiences, it is possible that the CFQ 2.0's validity may not generalise to participants without access to a computer and the internet.

The studies reported here instructed participants to respond regarding the frequency of cognitive failures in the past six months. There is some similarity between some items developed specifically for polling daily memory lapses (e.g., forgetting why entered a room (Mogle et al., 2023)) and those in the CFQ 2.0 (e.g., forgetting why went from one part of the house to another). Future research will be required to assess the CFQ 2.0's validity when participants are instructed to make their reports regarding shorter timescales, and whether it can outperform existing approaches in this space.

7.2. Conclusion

In conclusion, here we introduce the "Cognitive Failures Questionnaire 2.0": a new and improved measure of cognitive failures that has greater contemporary relevance, is shorter, and can explain more variance in objective attentional control performance than the original CFQ. The CFQ 2.0 consists of a single factor with 15 items (see Appendix B), which researchers are free to use with appropriate citation.

CRediT authorship contribution statement

Stephanie C. Goodhew: Conceptualization, Methodology, Software, Investigation, Formal analysis, Writing – original draft. **Mark Edwards:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

None to declare.

Data availability

Data are available here: https://osf.io/ak5um/.

Appendix A. High load items on factors from EFA in Study 1

Factor	Factor loading	Item	Original/new
1	0.687	Do you find you forget why you went from one part of the house to the other?	Original
1	0.573	Do you find you forget whether you've turned off a light or a fire or locked the door?	Original
1	0.562	Do you fail to hear people speaking to you when you are doing something else?	Original
1	0.593	Do you find you forget appointments?	Original
1	0.573	Do you find you accidentally throw away the thing you want and keep what you meant to throw away?	Original
1	0.656	Do you find you forget what you came to the shops to buy?	Original
1	0.544	Do you forget to take your keys with you?	New
1	0.505	Do you forget passwords you need to remember?	New
1	0.556	Do you receive a delivery and forget what you ordered?	New
1	0.527	Do you call people by the wrong name?	New

(*continued on next page*)

(*continued*)

Factor	Factor loading	Item	Original/new
1	0.621	In conversations, do you forget people's name even when you know them well?	New
1	0.552	Do you get the dates of things mixed up?	New
1	0.520	Do you find you go to put objects in the wrong place, like putting something from the cupboard in the fridge?	New
1	0.644	Do you leave home and later realise you have forgotten something you intended to bring with you?	New
1	0.590	Do you think something is missing, only to later see it where you had already looked?	New
2	0.533	Do you have trouble making up your mind?	Original
2	0.579	Do you find you can't think of anything to say?	Original
2	0.531	Do you put off doing important tasks?	New
2	0.621	Do you procrastinate?	New
2	0.823	Do you think over previous conversations?	New
2	0.934	Do you often feel overwhelmed by your emotions?	New
2	0.856	Do you get upset by things?	New
2	0.930	Do you worry about things?	New
2	0.892	Do you think negative thoughts or recall negative memories?	New
2	0.834	Do you worry about what other people think of you?	New
2	0.582	Do you eat unhealthy food and later regret it?	New
3	0.906	Do other people say you are organised? [RS]	New
3	0.601	When packing a suitcase, do you neatly fold items? [RS]	New
3	0.710	Do you keep your computer files in well-labelled folders? [RS]	New
3	0.972	Do you keep things neat and organised? [RS]	New
3	0.909	Are spaces that you have control over, like your room or your car, messy?	New

Note. RS = reverse-scored.
Note. The original item "Do you find you accidentally throw away the thing you want and keep what you meant to throw away?" includes the addition "– as in the example of throwing away the matchbox and putting the used match in your pocket?", which is how we worded it in Studies 1–3 here. However, on reflection, we suggest that this example is somewhat dated, and that it is more suitable to simply phrase the question: "Do you find you accidentally throw away the thing you want and keep what you meant to throw away?". This is the wording we used in Studies 4 and 5.
Note. Original/New column refers to whether the item is derived from the original CFQ 1.0 [original] or was a new item we developed in the present project [new].
Note. See Appendix B for final CFQ 2.0 items and instructions to administer to participants.

Appendix B. The Cognitive Failures Questionnaire 2.0

1. Do you find you forget why you went from one part of the house to the other?
2. Do you find you forget whether you've turned off a light or a fire or locked the door?
3. Do you fail to hear people speaking to you when you are doing something else?
4. Do you find you forget appointments?
5. Do you find you accidentally throw away the thing you want and keep what you meant to throw away?
6. Do you find you forget what you came to the shops to buy?
7. Do you forget to take your keys with you?
8. Do you forget passwords you need to remember?
9. Do you receive a delivery and forget what you ordered?
10. Do you call people by the wrong name?
11. In conversations, do you forget people's name even when you know them well?
12. Do you get the dates of things mixed up?
13. Do you find you go to put objects in the wrong place, like putting something from the cupboard in the fridge?
14. Do you leave home and later realise you have forgotten something you intended to bring with you?
15. Do you think something is missing, only to later see it where you had already looked?

Instructions to participants:

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. Please select the response that best reflects your experience in the past six months.

Response scale:

Never (0), Very Rarely (1), Occasionally (3), Quite Often (3), Very Often (4).

Permission:

Provided that the present work is appropriately credited, the CFQ 2.0 can be used for research purposes without personal permission.

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2023.112472.

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