**­­­­GPT API Models Can Function as a Highly Reliable Second Screener of Titles and Abstracts in Systematic Reviews**

**ABSTRACT**

Independent human double screening of titles and abstracts is considered a critical step to ensure the quality of systematic reviews and meta-analyses herein. However, double screening is a costly as well as a time- and resource-intensive procedure that slows the review process, ultimately excluding many researchers from using it. To alleviate this issue and potentially increase the reliability of systematic reviews and meta-analyses, we evaluated the use of OpenAI’s GPT (generative pre-trained transformer) API (application programming interface) models as an alternative second screener of titles and abstracts in systematic reviews. Overall, we found that the GPT API models perform on par or even better than common human screening performance in terms of detecting relevant studies. To support future reviews, we develop a reproducible workflow and tentative guidelines for when (and not) reviewers can use GPT API models for title and abstract screening. Our aim is ultimately to make a framework in which the uptake of using GPT API models can be accpeted as independent second screeners within reviews facilitated by evidence institutions such as Cochrane and Campbell Collaboration. To standardize this application of using GPT API models for title and abstract screening tasks, we present the R package AIscreenR.

**KEYWORDS:** *title and abstract screening, OpenAI’s GPT API models, systematic review, screening benchmarks, AIscreenR*

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**HIGHLIGHTS**

**What is already known**

* OpenAI’s GPT API models have shown promising performance in terms of working as a second screener of titles and abstracts within various scientific fields.
* Automating screening tools can ease the burden of title and abstract screening
* Automating screening tools most often cannot detect/classify all relevant studies, which in turn, can induce the so-called ‘artificial screening biases’

**What is new**

* We show that OpenAI’s GPT API models can function as a highly reliable second screener in social science reviews with better recalls than presented in previous evaluations and on par with human performance.
* We develop empirical benchmarks to make reliable comparisons between AI and human screening performances.
* We provide general guidelines for how and when GPT models safely can used
* We present and validate the R package AIscreenR to ensure standardized conduct of title and abstract screening with OpenAI’s GPT API models (and in theory with other models such as Claude 2).

**Potential impact for Research Synthesis Methods readers**

* Changing the double screening workflow of title and abstract screening in systematic reviews
* Increasing the reliability of large-scale systematic reviews
* Substantial and reliable reduction of human labor in systematic reviews
* Provides a new guideline for reviewers on when and when not to use AI screening tools
* Standardizing screening with prompt-based LLMs

**1 INTRODUCTION**

Systematic reviews are essential tools for informing policy, research, and practice. Hence, it is all-important that systematic reviews adhere to the highest scientific standards. Yet systematic reviews are time-consuming, potentially hindering a timely transfer of usable knowledge. Distinct from other types of reviews, systematic reviews are defined as the process of collecting, assessing, and synthesizing findings from (ideally all) relevant scientific studies using explicit and replicable research methods (Gough et al., 2017; Hou & Tipton, 2024). A critical first step to ensure the quality of systematic reviews and meta-analyses herein involves detecting all eligible references related to the literature under review (Polanin et al., 2019). This entails searching all pertinent literature databases relevant to the given review, most often resulting in thousands of title and abstract records that need to be screened. Manual screening hereof can be a time-consuming and tedious task. However, overlooking relevant studies in this phase can be consequential, potentially leading to substantially biased results if the missed studies are systematically different from the detected ones. In fact, this can be seen as a special case of publication/selection bias (Hedges, 1992; Rothstein et al., 2005), which threatens the internal validity of systematic reviews (Shadish et al., 2002). Therefore, independent human double-screening is considered to be the ’golden standard’ to hinder a biased selection of relevant studies (Guo et al., 2024; Higgins et al., 2019; Stoll et al., 2019; Wang et al., 2020). This is further supported by the fact that previous research suggests that screeners on average tend to miss between 3% to 24% of all eligible studies depending on the level of content knowledge, which most often has a substantial impact on the final quantitative results (Buscemi et al., 2006; Waffenschmidt et al., 2019). In medicine, this number is in some cases even higher when using student screeners (Ng et al., 2014). Nonetheless, duplicate screening of all identified titles and abstracts is a costly and resource-intensive procedure, potentially requiring several months of skilled, full-time human labor (Campos et al., 2023; Hou & Tipton, 2024; Shemilt et al., 2016). Consequently, many reviewers refrain from using duplicate screening methods due to low budgets or narrow time limits, for instance. Alternatively, reviewers make too narrow searches to keep the number of records down to a manageable size which again heavily increases the risk of overlooking relevant studies (Van De Schoot et al., 2021). Over time all these issues will only grow in size since the complexity of identifying all relevant studies increases with the rapid growth in the number of scientific publications (Bornmann et al., 2021; O’Mara-Eves et al., 2015). Thus, it can be considered an economically inefficient and unsustainable use of human resources only to rely on (duplicate) human screening of titles and abstracts in future systematic reviews[[1]](#footnote-1) (Shemilt et al., 2016), and changes are needed to maintain a high quality of large-scale systematic reviews.

A possible solution, and an alternative to human double-screening, is to use (semi-)automated screening tools based on text-mining and/or machine-learning algorithms to act either as a second screener, a course-grained classifier, or to sort citation records in prioritized order (Cohen et al., 2006; Gartlehner et al., 2019; O’Mara-Eves et al., 2015; Van De Schoot et al., 2021). The use of automated screening tools is considered invaluable in supporting living reviews and has shown a promising ability to reduce the screening workload by 30% to 70% (O’Mara-Eves et al., 2015; Perlman‐Arrow et al., 2023). However, a clear disadvantage of these substantial workload savings is that it is expected that they will always result in missing at least 5%-10% of all eligible references since ”a 100% recall rate with a stochastic algorithm is generally considered unattainable” (Hou & Tipton, 2024, p. 3). This seems to create a screening paradox which might be one of the main reasons why many reviewers tend to mistrust the application of machine-learning tools (O’Connor et al., 2019). While trying to reduce selection biases caused by single screening, automated screening potentially introduces a novel type of publication bias defined by König et al., (2023) as the ‘artificial screening bias’ (ASB).

An additional challenge is that most automated screening are based on supervised and active learning methods. This means that they need to be trained on a large enough set of in- and excluded references to perform adequately which in turn can be a time-consuming task. Moreover, when automation tools are used for prioritized screening, it is most often unknown when it is safe to stop screening with regard to finding all or close to all eligible references. Albeit, various stopping rules have been proposed, the adequacy of these is sensitive to a range of factors such as the length of the database, the prevalence of relevant studies, and the balance between relevant and irrelevant records (Campos et al., 2023; König et al., 2023; Van De Schoot et al., 2021).

To date, many automated screening tools have been thoroughly evaluated (Burgard & Bittermann, 2023). The overall picture is that they are generally not capable of replacing an independent human second screener without a significant risk of omitting a substantial number of eligible studies[[2]](#footnote-2) (Gartlehner et al., 2019; O’Mara-Eves et al., 2015; Olorisade et al., 2016; Rathbone et al., 2015). By using the level of automation heuristic (c.f. Table 1) developed by O’Connor et al. (2019), it can be said that current automated tools generally fail to function at the highest levels of automation (i.e., Level 3 and Level 4) where they make credible independent deterministic screening decisions. Instead, the vast majority of tools are predominately used to conduct Level 2 tasks such as sorting citation records in prioritized order from highest to lowest probability of being relevant to the review (O’Connor et al., 2019; Olofsson et al., 2017). If considerable time savings should be realized in future reviews, it is regarded as all-important that automated tools rise to at least Level 3 of automation (Jonnalagadda et al., 2015; Tsafnat et al., 2014).

**Table 1.** Levels of automation for human-computer interactions\*

|  |  |
| --- | --- |
| **Level** | **Task** |
| Level 4 | Tools perform tasks to eliminate the need for human participation in the task altogether, e.g., fully automated article screening decision about relevance made by the automated system. |
| Level 3 | Tools perform a task automatically but unreliably and require human supervision or else provide the option to manually override the tools’ decisions, e.g., duplicate detection algorithms and software, linked publication detection with plagiarism algorithms and software. |
| Level 2 | Tools enable workflow prioritization, e.g., prioritization of relevant abstracts; however, this does not reduce the work time  for reviewers on the task but does allow for compression of the calendar time of the entire process. |
| Level 1 | Tools improve the file management process, e.g., citation databases, reference management software, and systematic  review management software. |

\*Adopted from O’Connor et al. (2019)

A possible solution to bridge the gap between Levels 2 and 3 of automation[[3]](#footnote-3) is to use the newly developed large language models (LLM), such as the generative pre-trained transformer (GPT) models introduced by OpenAI. The first evaluations of using OpenAI’s GPT API (application programming interface) models for screening of medical and software engineering titles and abstracts have generally yielded promising results with recall and specificity measures in most instances on par with human performance but always on par or superior to classical machine-learning tools (Guo et al., 2024; Syriani et al., 2023).

Although previous applications and evaluations of using OpenAIs GPT models for title and abstract screening (henceforth TAB screening) represent a vital first step for validating the use of GPT models as independent second screeners in systematic reviews, many questions are left unanswered. Most pressing, it is still unclear how the GPT models can be implemented in systematic reviews in a standardized and reliable manner. In contrast to many well-established automated screening algorithms, there exists no recommended workflow for how to conduct such screenings, including how to make reliable prompts. Even more critically, no software[[4]](#footnote-4) has yet been developed to support and standardize the setup of this screening approach. Therefore, a major aim of this paper is partly to develop a heuristical workflow for how to conduct TAB screening with GPT API models and partly to present the R package AIscreenR (version 0.0.1). Our target goal is to develop an easy-to-implement framework that draws on commonly accessible RIS file data typically used with standard review software such as Covidence and EPPI-reviewer, etc. This might increase the chances of ensuring user deployment and acceptance since complex implementation is often considered to be a major impediment to the wider application of automated screening tools (O’Connor et al., 2019).

Furthermore, there has not yet been laid any solid foundation on which evidence institutions (such as Cochrane and the Campbell Collaboration) can accept and recommend the use of such tools per se. According to the Campbell Collaboration, for them to accept the incorporation of automation tools in their reviews “*requires (a) functioning tech (b) proof that it is functioning appropriately (c) the tech embodied in usable products (d) agreed guidelines for appropriate use (e) training (f) ongoing support.*” (Campbell Collaboration, 2023). Therefore, the overarching goal of this paper is to construct a framework in which TAB screening with GPT API models can be said to meet requirements set forth by the evidence institutions. In the following part, we briefly explicate how we aim to build this framework.

Concerning requirement *(a)*, we cannot as such fulfill it since the GPT API models we draw upon in this paper are closed-source applications with black-box algorithms. That is our suggested framework is only viable as long as given firms provide access to their LLMs. However, our suggested framework and codes can readily be remodeled to work with other API models, such as models from Claude 2 or Mistral AI where the request body takes the same arguments as OpenAI’s GPT models. Therefore, our setup aims to be agnostic to the given provider of the given LLM. In theory, our approach can be implemented together with LLMs such for instance Mistral open-source LLMs that can be downloaded locally by the users. We, therefore, understand a “functioning tech” to point, in our case, to the broader family of LLM models, which we believe will be around in some or another form for many years.

A key part of fulfilling Campbell’s requirement *(b)*, and not compromising the quality of future systematic reviews, is to show that the GPT API models are not significantly inferior to human screening performance (O’Connor et al., 2019). Thus to make a reliable assessment of this, we developed empirical screening benchmarks to which the GPT API screening performance can be compared. We consider this as the only reliable way to assess whether a given recall is good or bad. Say, for example, that if humans on average tend to miss 20%-25% of all relevant studies during the title and abstract screening phase, then it might be misleading to infer that GPT models with a recall of 0.75% imply that GPT cannot be used as an individual second screener. To construct such a benchmark scheme we mapped the human screening performance of 21 large-scale systematic reviews; 16 Campbell Systematic Reviews, and five systematic reviews conducted by the Norwegian Institute of Public Health (NIPH). Thereafter, we conducted two large-scale classification experiments, where we showed that OpenAI’s GPT API models can conduct TAB screening with a performance *at least* on par with human performance relative to our developed benchmarks.

We aim to fulfill requirement *(c)* by developing the AIscreenR software. A side-effect of conducting the above-mentioned classifier experiments, mentioned under requirement *(b)*, was further to ensure that the AIscreenR package works reliably.

Then, to fulfill requirements *(d)* and *(e),* we develop a heuristic for how to test the performance of one’s developed prompt(s) and screening as well as assess under what conditions TAB screening with the GPT API models can be accepted to be used as an independent second screener in systematic reviews. We inform these guidelines by the empirical human screening benchmarks developed under requirement *(b)* as well. Since we are working with pre-*trained* models, requirement *(e)* is not as such necessary in our case. Instead, the performance of the prompt(s) used for screening needs to be *tested* and compared against human performance measures before credible TAB screening can be initiated. We return to this point when we show how to develop reliable prompts for TAB screening in later sections. Finally, to accommodate requirement *(f)* we have developed the AIscreenR package as an open-source software so that others in the review community can readily contribute to the development and ongoing support of the software. With the exposition sketched above, we hope to make the uptake of such tools more acceptable and clearer in future reviews. This goes without saying that our approach represents the final solution. Our aim is just to show one way in which GPT API models can be used for TAB screening in large-scale systematic reviews that can inspire future applications of TAB screening with LLMs.

The remainder of the paper proceeds as follows: In Section 2 we review previous evaluations of using OpenAI’s GPT models for TAB screening tasks in systematic reviews and reflect on our contributions. In Section 3 we describe the metrics we applied to evaluate the screening performance of the GPT API models and human screeners, respectively. In Section 3, we further develop screening performance benchmarks to assess the performance of the GPT API models. In Section 4, we sketch our used prompt engineering and how we think reliable prompts can be developed. In this regard, we also describe in more detail the advance of using function calling with the GPT API models to ensure reliable response messages. In Section 5, we present the data used to conduct the two large-scale classifier experiments and the results of these experiments. In section 6, we deduce tentative guidelines for when we think reviewers are ‘good to go’ in terms of using OpenAI’s GPT API models as an independent second screener. Finally, in Sections 7 to 9, we recapitulate by reflecting on the limitations of our work and the use of OpenAI’s LLMs and what should concern future research as well as the implications of our results and recommendations.

**2 RELATED WORK**

To our knowledge, the first evaluation of the TAB screening performance of OpenAI’s GPT API models was performed by Syriani et al. (2023). Based on five ongoing systematic reviews within the field of software engineering, they compared the TAB screening performance of the GPT API model 3.5-turbo-0301[[5]](#footnote-5) relative to five state-of-the-art machine learning algorithms. Hereto they found that OpenAI’s GPT API models perform on par with traditional classifier models, and in some instances even better—without any need for (pre-)training. They only found the models to perform badly when applied on datasets where humans had shown a “high conflict ratio”. This might simply indicate that the models perform badly when given unclear inclusion criteria—as humans would do too. Syriani et al. (2023) used Python to reach the GPT API models, but they did not build any publicly available software for others to replicate their workflow.

Guo et al. (2024) tested the leverage of OpenAI’s GPT-4 API model[[6]](#footnote-6) for TAB screening of medical research literature. They found that the average recall (referred to as the sensitivity of included paper) and specificity when compared to the final decision of two independent human screeners across six clinical reviews was 0.76 and 0.91, respectively. Based on these results, Guo et al. (2024) infered that the GPT-4 model is proficient in terms of excluding the right studies whereas it is insufficient in finding relevant studies compared to human screening. Consequently, Guo et al. (2024) conclude that GPT API models should not replace human screening but instead be seen as a support tool guarding against human errors. Guo et al. (2024) used Python to call the API models without providing any general user software.

Gargari et al. (2024) applied the GPT-3.5-turbo-0613 API model to conduct TAB screening in one clinical systematic review. In line with Guo et al. (2024), they found GPT to be better at making correct exclusion decisions relative to detecting relevant studies. Therefore, they also recommend not replacing any human raters with the GPT-3.5 API model. Gargari et al. (2024) reached the API model via Python, and they shared their codes[[7]](#footnote-7) so that others can replicate their workflow. Yet this requires reviewers to be rather skilled in Python coding.

On a related line of research, Alshami et al. (2023), [Khraisha](https://onlinelibrary.wiley.com/authored-by/Khraisha/Qusai) et al. (2024), and Issaiy et al. (2024) all investigated the TAB screening performance of using ChatGPT from the internet interface. Alshami (2023) found that using the ChatGPT interface exhibits performance measures similar to the API model. By contrast, [Khraisha](https://onlinelibrary.wiley.com/authored-by/Khraisha/Qusai) et al. (2024) and Issaiy et al. (2024) found that using GPT-3.5 and GPT-4 via the ChatGPT interface worked insufficiently compared to human performance. As we will later discuss further, we found a similar pattern when we compared the performance of OpenAI’s GPT API models with that of the ChatGPT interface. To be precise, the GPT API models reached from the *v1/chat/completions* endpoint worked significantly better relative to the GPT models embedded in the ChatGPT interface. In fact, we were not able by any means to replicate our results obtained from the API models with the models available in the ChatGPT interface. We, therefore, consider it pivotal that future research clearly distinguishes between OpenAI’s GPT models when doing research with them so that the performance of different GPT models is not unnecessarily mixed up. In the paper, we narrowly focus on the use of OpenAIs GPT API models reached from the ‘v1/chat/completions’ endpoint, not to be confused with the GPT models behind the ChatGPT interface or the ‘v1/completions’ endpoint. On this note, it was unclear what exact model Syriani et al. (2023) and Guo et al. (2024) used during their investigations, whereas Gargari et al. (2024) used the same endpoint as we drew upon in this paper.

**2.1 What we do differently**

In this paper, we go beyond previous evaluations in multiple ways and show some key advances in using LLMs for TAB screening relative to (but possibly combined with) traditional machine learning tools. Starting with the latter, one advance of using LLMs is that these models do not need to be pre-trained which, in turn, means that these models are not as (if at all) sensitive to imbalance between relevant and irrelevant records or the number of relevant records in the data as classical machine-learning tools (Campos et al., 2023; König et al., 2023). This is so because the GPT models we applied treat each title and abstract individually without any knowledge of previous decisions. Compared with traditional machine learning algorithms, we will also show that the GPT-4 has the ability to find almost all relevant studies when well prompted.

In contrast to all the previous evaluations of using GPT API models for TAB screening, we are the first to draw on the function calling in the request body (OpenAI, 2024). This allows users to make prompts without the need to explicitly specify how the model shall respond to a request. The specific advance of function calls is that this permits users to make more refined and concise prompts, which, in turn, ensures that users are getting “more reliably (…) structured data back from the model” (OpenAI, 2024). We believe that the use of function calling potentially explains why we in later sections find significantly better recall performances (i.e., the ability to detect relevant studies) of using the GPT API models than previous evaluations. Differently from the previous evaluation, we have built our function calls so that they also allow the model to express its uncertainty relative to just making binary decisions (i.e., include or exclude) as all previous evaluations have done. That is if the GPT API model, for example, does not have enough information to make a reliable decision, the given title and abstract is added to the pool of included studies. This significantly reduces the models' ability to overlook potentially relevant studies. Moreover, we built two different types of function calls thus that users can both get simple/trinary (i.e., 1 = {include}, 1.1 ={uncertain}, and 0 = {exlcude}) and/or descriptive responses back from their screening requests. Getting detailed descriptive responses can be pivotal especially when examining discrepancies between GPT and human screener decisions.

The main difference between this paper and the previous evaluation is further that we aim to make a standardized and user-friendly workflow for how to use GPT API models for TAB screening that are easy to implement in state-of-the-art systematic reviews. We do so by developing the AIscreenR R package and technically quality-assuring it via the conduct of to large-scale classifier experiment. The AIscreenR is built as a flexible software that allows users to conduct multiple screenings simultaneously based on multiple prompts, API models, iterations of the same request, and nucleus samples (i.e., different top\_p values). We allow the user to conduct the same request (i.e., asking the exact same question) multiple times to avoid random noise in the model response (especially when using gpt-3.5 models). When this feature is used the final GPT decision is based on the probability of inclusion across the iterated requests. The inclusion threshold can be determined by the user. This also allows the users to test model response consistency. Moreover, the software is built so that it draws on multi-core processing, which allows the users to speed up the timing of the screening significantly.

To conduct a fair assessment of GPT's ability to conduct TAB screening relative to humans but also to outline reliable guidelines on when to use LLMs for TAB screening (which has not previously been done), requires a clear understanding of common human screening performance in systematic reviews. Therefore, to make a better understanding of common human performance and to develop benchmarks that could be held against the screening performance of GPT, we mapped the human screening performance across 16 Campbell systematic reviews and 5 systematic reviews conducted by the Norwegian Institute of Public Health (NIPH). Relative to the previous evaluations, the contribution of this paper is therefore to put forward a tentative benchmark scheme to which all types of AI screening tools can be compared.

In all the previous evaluations, multiple inclusion/exclusion criteria were added to a single prompt. Yet Gargari et al. (2024) suggested that broader and less specific prompts do not perform well in terms of finding relevant studies. Instead, concisely framed prompts with clear information seem to have a better performance. This could indicate that single-prompt TAB screening is rather restricted to only work within simple and clearly defined reviews where the inclusion of abstracts can be determined by a few inclusion criteria/questions. However, to overcome this issue, we introduce what we have coined *hierarchical screening*. With this approach, we suggest making one concise prompt per inclusion (and/or exclusion) criterion. In the type of screening, studies are only considered relevant if included on all or close to all (say 5 out of 6) of the used prompts. We consider this to represent a reliable and viable way in which TAB screening with GPT API models is also within broad and complex reviews, as we often find within the social sciences.

Finally, all previous evaluations were based on medical or natural science reviews, and we add to the generalizability of these results by showing that GPT API models all exhibit promising screening performance in the more wildly social science reviews as well.

**3 METHODS**

This section describes the metrics that we used partially to evaluate the screening performance of the GPT API models and partially to develop empirical screening benchmarks to hold against the screening performance of the used GPT API models. Moreover, the section describes the data and results we used to develop our suggested screening performance benchmarks.

**3.1 Metrics we use to evaluate the performance of the GPT models**

To evaluate the screening performance of the GPT API models, we used a range of different metrics. The choice of metric was primarily informed by the recommendations made by O’Connor et al. (2019) and Syriani et al. (2023). The two main metrics we used to evaluate the performance of the GPT API models were the *recall* (by some defined as the sensitivity) and *specificity* metrics since these are intuitive to understand and interpret and are not sensitive to imbalanced data (i.e., data with a large differences in the proportion between inclusion and exclusion references, as is commonly the case in systematic reviews). The recall metric “represents the proportion of relevant records being correctly classified” (Hou & Tipton, 2024), and can be written as

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where (true positive) represents all the studies that are correctly included, and (false negative) is the number of studies falsely excluded. By contrast, the specificity metric “measures the ability to exclude all references that should be excluded” (Syriani et al., 2023), and is given by

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

where (true negative) represents all the studies that are correctly excluded, and (false positive) is the number of studies falsely included. In this regard, we consider the recall measure to be the absolute most important performance measure in our case since missing relevant studies, that is having a low recall, is the main reason for automated tools to potentially introduce a serious bias in systematic reviews (Hou & Tipton, 2024). Whereas, a low specificity “just” means that reviewers must re-examine the relevancy of a larger share of the pool of references. If reviewers can be sure that they find all relevant studies but have a specificity of say 50%, this still implies that the reviewer can safely exclude 50% of the irrelevant records, which in most instances can be considered to be a significant reduction in the screening workload. Therefore, we think that automated tools should be accepted as long as they come close to scenarios A and B pictured in Figure 1. That is, they are accepted when high recalls can be made to a large extent independently of the accordingly specificity measure. Yet, this goes without saying that reviewers should accept low specificity rates. We will come back to that in the following sections.

In our classifier experiment, the , , , and conditions were determined by comparing the GPT decision with the final decision made by a minimum of two independent human screeners. For our benchmark development, the conditions were determined by comparing the single human screener decision with the final decision agreed upon between a minimum of two human screeners.

**Figure 1: Recall and specificity performances**

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| --- | --- |
| A: High recall, high specificity  Irrelevant  Relevant    Included by GPT | B: High recall, low specificity  Irrelevant  Included by GPT  Relevant |
| C: Low recall, high specificity  Irrelevant  Relevant  Included by GPT | D: Low recall, low specificity  Relevant  Included by GPT  Irrelevant |

Note: The blue-colored circles indicate the proportion of relevant title and abstract records; the gray-colored circles represent the proportion of records included by the screener; the white circles represent the proportion of irrelevant records that are correctly excluded by the screener.

The two above metrics concern the inclusion or exclusion performances individually but it might also be desirable to include metrics that incorporate the overall performance across the inclusion and exclusion metrics. A typical issue with such metrics is that they are very sensitive to imbalances in the data. That is for example when the proportion of irrelevant records is much larger relative to the proportion of relevant records, which is most often the case in systematic reviews. To exemplify, if one simply uses the raw agreement metric with imbalanced data then the screening performance will most often be overestimated. For example, assume that you have 10 relevant records per 1000 records, then you could end up reaching a raw agreement of 99% if the given screener just excluded all records. Although the screening performance seems to be high it clearly hides the fact that the given screener was unable to detect any relevant studies. To overcome this issue, we used two overall metrics that account for imbalances*.* That is *the balanced accuracy* and *the normalized Matthew correlation coefficient* . The former balances the accuracy of the performance across the recall and specificity metrics and is simply an average of those metric, and is given by

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

The metric, on the other hand, is considered to be the metric that mostly maximizes the use of the four quantities, *TP, TN, FP, FN* and it has been shown to have better statistical properties than other popular metrics such as the Receiver Operating Characteristic Curve (ROC AUC) (Chicco & Jurman, 2023). It can be calculated as follows.

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

**3.2 Human screening performance for benchmark development**

In order to make fair comparisons between human and automated screening performances, we consider it pivotal to have a deeper understanding of acceptable human screening performance in high-standard systematic reviews. This was highlighted by O’Connor et al. (2019) as well. We believe that many previous evaluations of the performance of automated screening tools overlook the fact that individual human screening is not without significant errors either, and automated screening tools must be evaluated in light of this. If we as a community primarily assess the performance of automated tools and accept the tools with the requirement that they can detect (close to) all relevant studies in all instances or on par with very high human performances, then the tools are by design doomed to fail. Automated screening tools will always err to some degree, as will humans (Waffenschmidt et al., 2019), and the important factor here is to ensure that the difference between the error rates is acceptable. What is acceptable is of course up to discussion but in this section, we develop a tentative benchmark scheme on which recommendations for how big error rates should be accepted in high-standard systematic reviews when using automated screening tools TAB screening

**3.2.1 The data underpinning the benchmark scheme**

The data we used to construct this benchmark scheme was based on the human screening performances in 21 high-standard systematic reviews that used independent duplicate human screening. This includes 16 Campbell Systematic Reviews and 5 reviews conducted by the Norwegian Institute of Public Health (NIPH). A descriptive overview of all the included reviews can be found in Table 2, including the imbalances in the given dataset. The included Campbell systematic reviews, represent all Campbell reviews that have been conducted by the Danish Center for Social Science Research in which independent duplicate human screening has been used and tracked. Concretely, this data includes 137,764 title and abstract records, all of which have been double-screened by 44 individual screeners of which 33 were student assistants and/or non-content experts, and 11 were researchers/authors of the given review, respectively. The Campbell reviews were conducted from 2015 to 2024. Since all of the included Campbell reviews drew on student assistant screeners, this could potentially downward bias the evaluation metrics for various reasons. For example, student assistants might lack sufficient profound content knowledge regarding the topic under review, potentially hindering them from reaching high recall rates. Thus their performances might not necessarily be comparable with the common screening performance of content expert screeners. Therefore, we analyzed the Campbell review data separately for student/non-expert and researcher/expert screeners. However, relative recall and specificity rate differences between the two types of screeners could also be driven by authority imbalances between the often more senior content expert and the student screener, making the performances of the expert screeners look better than they actually were. Consequently, we added the screening performance data from five systematic reviews conducted by NIPH in which all TAB screenings and disagreements were conducted and solved by researchers with specific content knowledge related to the given review. This should, thereby, give a clearer picture of common researcher performances in systematic reviews. This data added a further 13,825 title and abstract records that had been independently double-screened by 13 individual researchers. The five NIPH reviews were conducted from 2021 to 2024. When analyzing all of the above-presented data, we removed all training data to avoid inflating human disagreements unreliably. In other words, all presented screening performances represent after-training screening performances.

**Table 2: Description of studies used to develop benchmark scheme**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Source**  **Authors** | **Short title** |  | **Ass.a** | **Aut.b** |
| *Campbell review* |  |  |  |  |
| Bøg et al. (2018) | Deployment of personnel to military operations | 106/2899 | 2 | - |
| Bondebjerg et al. (2023) | The effects of small class sizes on students’ academic achievement, socioemotional development and well‐being in special education | 244/11860 | 4 | 2 |
| Dalgaard, Bondebjerg, Klokker et al. (2022) | Adult/child ratio and group size in early childhood education or care to promote the development of children aged 0–5 years | 258/3667 | 4 | 2 |
| Dalgaard, Bondebjerg, Viinholt et al. (2022) | The effects of inclusion on academic achievement, socioemotional development and wellbeing of children with special educational needs | 373/14491 | 5 | 2 |
| Dalgaard, Filges et al. (2022) | Parenting interventions to support parent/child attachment and psychosocial adjustment in foster and adoptive parents and children | 424/13106 | 3 | 2 |
| Dalgaard, Jensen et al. (2022) | PROTOCOL: Group‐based community interventions to support the social reintegration of marginalised adults with mental illness | 557/17614 | 4 | 3 |
| Dietrichson et al. (2020, 2021) | Targeted school-based interventions for improving reading and mathematics for students with or at risk of academic difficulties in Grades K-6 [plus 7-12] | 2952/15273 | 6 | 1 |
| Filges, Dalgaard et al. (2022) | Outreach programs to improve life circumstances and prevent further adverse developmental trajectories of at-risk youth in OECD countries | 387/4890 | 4 | - |
| Filges, Dietrichson et al. (2022) | Service learning for improving academic success in students in grade K to 12 | 619/6269 | 4 | 1 |
| Filges, Montgomery, et al. (2015) | The Impact of Detention on the Health of Asylum Seekers | 573/10061 | 2 | - |
| Filges, Siren et al. (2020) | Voluntary work for the physical and mental health of older volunteers | 43/14919 | 2 | 0 |
| Filges, Smedslund et al. (2023) | PROTOCOL: The FRIENDS preventive programme for reducing anxiety symptoms in children and adolescents | 96/2745 | 1 | 1 |
| Filges, Sonne-Schmidt et al. (2018) | Small class sizes for improving student achievement in primary and secondary schools | 303/7802 | 5 | 1 |
| Filges, Torgerson, et al. (2019) | Effectiveness of continuing professional development training of welfare professionals on outcomes for children and young people | 298/5147 | 1 | 4 |
| Filges, Verner et al. (2023) | PROTOCOL: Participation in organised sport to improve and prevent adverse developmental trajectories of at-risk youth | 158/7021 | 2 | 1 |
| *NIPH review* |  |  |  |  |
| Ames et al. (2024) | Acceptability, values, and preferences of older people for chronic low back pain management | 144/425 | - | 2 |
| Evensen et al. (2023) | Sutur av degenerative rotatorcuff-rupturer [Rotator cuff repair for degenerative rotator cuff tears] | 418/2499 | - | 4 |
| Jardim et al. (2021) | Effekten av antipsykotika ved førstegangspsykose [The effect of antipsychotics on first episode psychosis] | 73/3924 | - | 3 |
| Johansen et al. (2022) | Samværs-og bostedsordninger etter samlivsbrudd [Custody and living arrangements after parents separate] | 143/1525 | - | 4 |
| Meneses Echavez et al. (2022) | Psykologisk debriefing for helsepersonell involvert i uønskede pasienthendelser [Psychological debriefing for healthcare professionals involved in adverse events] | 45/5452 | - | 3 |

*Note*: *a*. Ass. denotes student/non-content expert screener; *b* Aut. denote authors of the review

**3.2.2 Statistical analysis used to deduce benchmarks**

From the data presented in the previous section, we estimated all the performance metrics via Equations (1) to (4). The , , , and conditions used in these equations were determined by comparing the single human screener decision with the final decision agreed upon between a minimum of two human screeners. When working with proportion metrics such as the ones presented in Equations (1) to (3), it is usually advantageous to transform these metrics into measures that have more appropriate statistical properties. This includes having a sampling distribution that more closely mirrors a normal distribution and a variance component that can more reliably be approximated (Viechtbauer, 2022). Therefore, we used the arcsine transformation (Röver & Friede, 2022; Schwarzer et al., 2019) to calculate sampling variance and confidence intervals for the recall, specificity, and balanced accuracy metrics. For the balanced accuracy metric, we calculated the sampling variance of the transformed measure by using the total number of records as the sample size. We did not use double arcsine transformation (Doi & Xu, 2021) due to the inadequate properties of the back transformation of this measure (Röver & Friede, 2022; Schwarzer et al., 2019). For the *nMCC* metric, we calculated the sampling variance and confidence interval by transforming the correlations to Fisher’s z-scores, as typically done in meta-analysis (Borenstein et al., 2009).

To derive the overall average performances across the , , , and the metrics, we fitted two versions of the so-called *correlated-hierarchical effects* (CHE) working models (Pustejovsky & Tipton, 2021). For investigation related to the differential performances between student and author screeners, we applied the so-called *subgroup correlated effects* (SCE+) model, whereas we used the CHE-RVE model when analyzing the NIPH performances. Both types of models account for the multi-level structure with performance measures nested within studies. At the same time, the models account for the correlation between the within-study performance estimates. The sample correlation, , is often entirely or partially unknown and must be imputed. In all the used working models, we assumed . To guard against model misspecification both models have incorporated robust variance estimators. The main difference between the two models is that the SCE+ model allows to derive subgroup effects from the same model, allowing for reliable contrast tests (Pustejovsky & Tipton, 2021). For differential effects comparisons, we used the HTZ Wald test suggested by Tipon and Pustejovsky (2015). Across both models, we estimated two sources of heterogeneity. That is the true variability of the performances within () and between studies (). This allowed us to investigate at what level the largest true difference between the human screener performances existed.

**3.2.3 Results**

All the individual screening performances across the included reviews and how these are distributed around the overall performance means are exhibited in Figures 2 and 3. We found the overall average recall rate for the assistant and author screeners in the included Campbell reviews to be 0.786, 95% *CI*[0.747, 0.823] and 0.892, 95% *CI*[0.841, 0.934], respectively. Hereto, we found the two average group differences to be statistically (significant) distinct from each other with *F*(1, 9.79) = 21.9, *p* < 0.001. The overall average specificity for assistant screeners was 0.980, 95% *CI*[0.966, 0.990], and for review authors 0.989, 95% *CI*[0.979, 0.995]. We found no statistically significant difference between the two average estimates. That is *F*(1, 12.31) = 1.64, *p* = 0.22. For assistant screeners, the average balanced accuracy was 0.877, 95% *CI*[0.860, 0.893], and for authors screeners it was 0.941, 95% *CI*[0.905, 0.968]. We found the difference between the groups to be statistically significant with *F*(1, 10.1) = 18.52, *p* = .0015. Finally, the overall was 0.859, 95% *CI*[0.831, 0.882] and 0.931, 95% *CI*[0.892, 0.956] for the assistant and author screeners, respectively. These averages were found to be statistically different with *F*(1, 9.87) = 14.93, *p* = .003.

Based on these results it might look like that research screeners are substantially better at detecting relevant studies relative to assistant screeners. Yet this difference can driven by other reasons than the actual screening performance of the assistants. Interestingly, when investigating the NIPH data, which was only based on researcher-researcher screening comparisons, we found performance patterns similar to the performance of the assistant screeners in the included Campbell review. The overall recall rate in the NIPH data was 0.839, 95% *CI*[0.737, 0.920]. Again, we primarily found true differences between the screener recall performances within studies with = 0.172 and = .0. The overall average specificity rate was 0.977, 95% *CI*[0.955, 0.992], with minor true variability both within and between studies. That is = 0.049 and = 0.037. The overall average balanced accuracy and were 0.905, 95% *CI*[0.859, 0.943] and 0.879, 95% *CI*[0.720, 0.951], respectively

With these results in mind, we suggest that automated tools with recall equal or close to having a recall of 80% and specificity rates above 95%) used be accepted

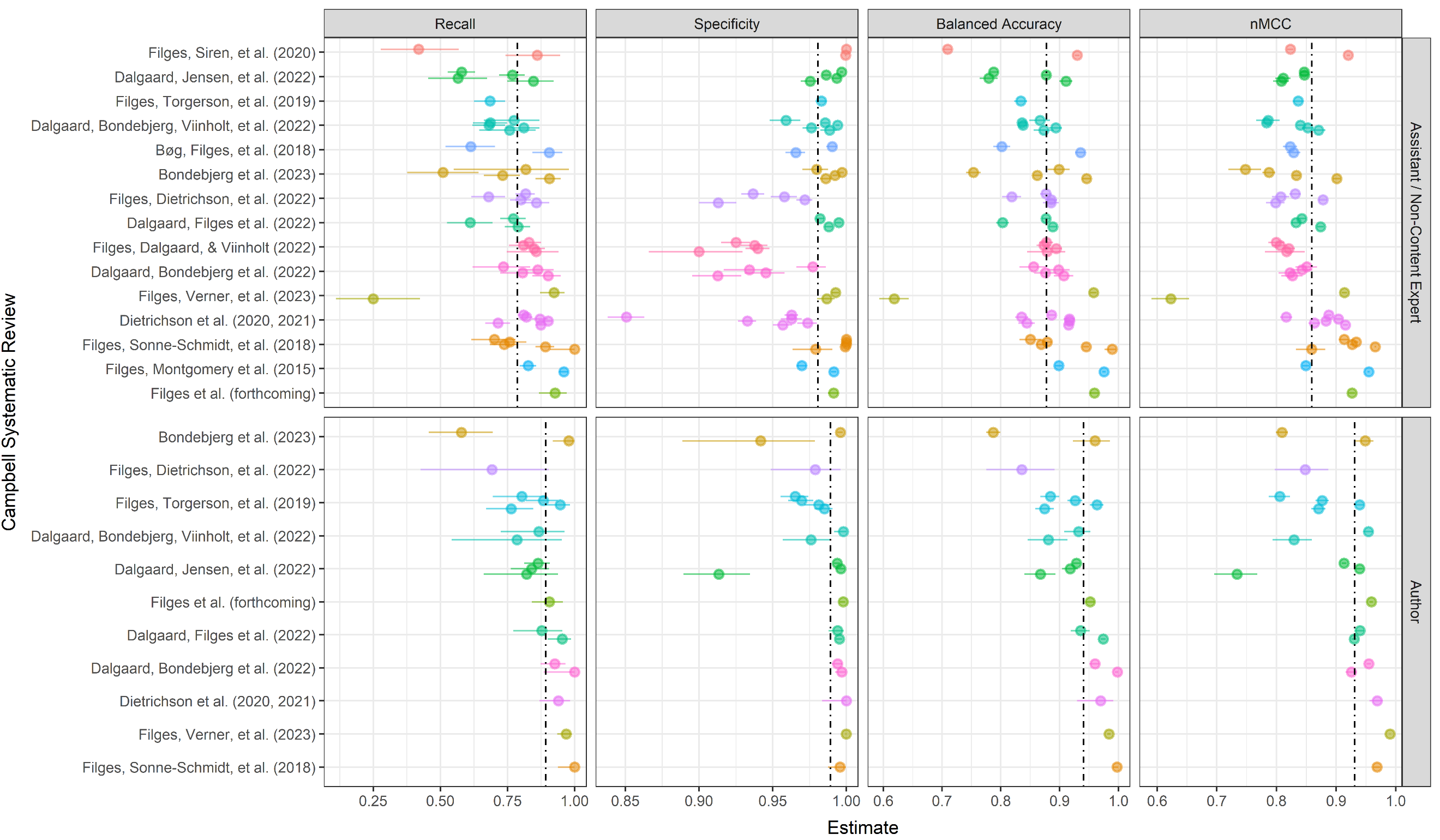


FIGURE 1. Performance measures within Campbell Systematic Reviews across assistant vs. author screeners. Dashed line indicate the average estimated via the SCE+ model.



FIGURE 2. Researcher-researcher screening performance measures within NIPH Systematic Reviews. Dashed line indicate the average estimated via the CHE model.

**3.3 Transparency and openness**

All data and codes behind our developed benchmarks scheme and classifier experiment are available at [bit.ly/3spivoG](https://bit.ly/3spivoG).

**4 PROMPT DEVELOPMENT AND FUNCTION CALLING**

We made the mistaking believing that we needed to add a whole lot of information to the prompt, that is we worked in the beginning with the prompt engineering as if we were training the model

*Prompt engineering* excerpt. This prompt was developed in less than 5 minutes.

*“We are screening studies for a systematic literature review. The topic of the systematic review is the effect of the FRIENDS preventive programme on reducing anxiety symptoms in children and adolescents. The FRIENDS programme is a 10-session manualised cognitive behavioural therapy (CBT) programme which can be used as both prevention and treatment of child and youth anxiety. The study should focus exclusively on this topic and we are exclusively searching for studies with a treatment and a comparison group. For each study, I would like you to assess: 1) Is the study about the FRIENDS preventive programme? 2) Is the study estimating an effect between a treatment and control/comparison group?”*

Then when given study id, title and abstact the AIscreenR automatically pastes together the above text with the following text:

*“Now, evaluate the following title and abstract for Study [the study id is inserted here]: -Title: [the study title is inserted here] -Abstract: [the study abstract is inserted here]”*

How the models should respond to the above request where given to the model via fucntion calling (OpenAI, 2024)

In hindsight, there was no need to add multiple inclusion criteria to a single prompt but it seems not to matter when working with simple screening cases. The more concise, the better performance of the screening. Therefore, we suggest using hierarchical screening when multiple inclusion/exclusion criteria are applied in the screening.

**Figure x: Hierarchical screening**

Prompt 1:   
With inclusion/exclusion criertion 1

*If included, the record moves to next prompt, otherwise the record is excluded*

Prompt 2:   
With inclusion/exclusion criertion 2

*If included, the record moves to next prompt, otherwise the record is excluded*

Prompt 3:   
With inclusion/exclusion criertion 3

*Continue as long as necessary*

Prompt x:   
With inclusion/exclusion criertion x

Ideally, order to prompts so that the ones excluding most references come first. Th will make the screening for efficient and thus cheaper as well.

**5 CLASSIFIER EXPERIMENT**

**5.1 Simulation data**

FRIENDS and FTT, only citation records with abstracts. We do not aim to show that GPT API models works for every single type of review. We are more interested in setting up general guidelines that if these are accommodate you can use the GPT API model. We don’t believe that GPT API models are appropiate in all reviews but we believe that they can be valuable in many review if used correctly

What type of reviews.

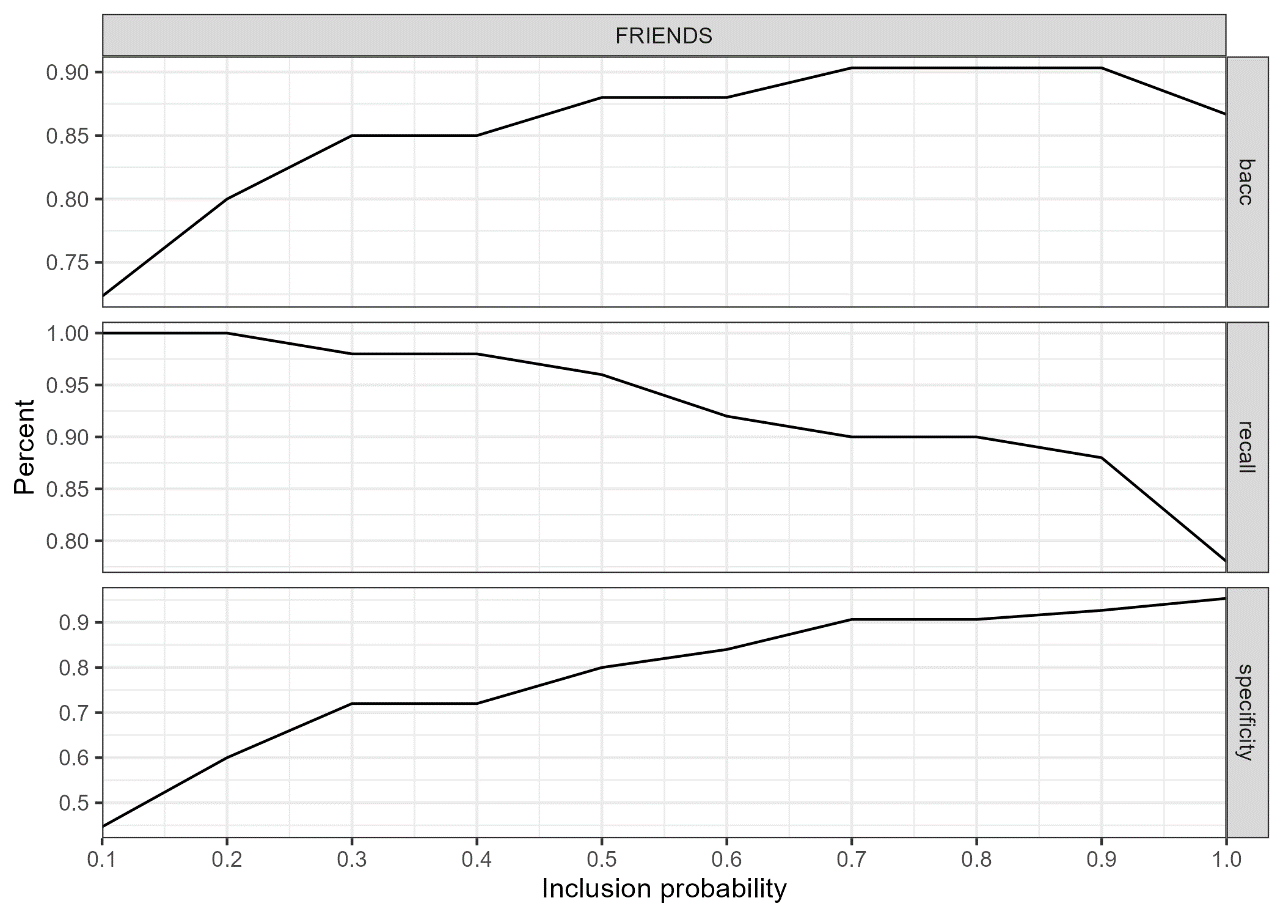
We did

How many titles and abstracts used. Trained with 200 records. Retrospective data. We used FRIENDS to show that the pre-training issue does not affect the performance of the GPT models.

**5.2 Results**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Review**  **Model** | **Reps** | **Recall (%)**  **[TP/(TP + FN)]** | **Specificity (%)**  **[TN/(TN + FP)]** | **Raw aggrement (%)**  **[(TP + TN)/]a** | **bAcc**  **(%)** |
| *FFT* |  |  |  |  |  |
| GPT-3.5-turbo-0613  (incl. prop = .5) | 10 | 71  (49/69) | 95.6  (3888/4066) | 95.2  (3937/4135) | 83.3 |
| GPT-3.5-turbo-0613  (incl. prop = .3) | 10 | 81.2  (56/69) | 93.7  (3809/4066) | 93.5  (3865/4135) | 87.4 |
| GPT-4-0613 | 1 | 89.9  (62/69) | 93.7  (3810/4066) | 93.6  (3872/4135) | 91.8 |
| *FRIENDS* |  |  |  |  |  |
| GPT-3.5-turbo-0613  (incl. prop = .5) | 10 | 96.9  (62/64) | 76.5  (1930/2511) | 77.1  (1992/2575) | 86.7 |
| GPT-3.5-turbo-0613  (incl. prop = .7) | 10 | 95.3  (61/64) | 89.8  (2256/2511) | 90.0  (2317/2575) | 92.6 |
| GPT-4-0613 | 1 | 98.4  (63/64) | 97.7  (2455/2511) | 97.4  (2518/2585) | 97.9 |

*a*: is the total number of references



Concise text more important than information-dense prompt.

GPT-3.5-turbo is sensitive to the number of times a reference is included across the 10 iterations. If 3.5 models are used then this most efficient threshold must be determined in the test phase.

The adequacy of the GPT 3.5 models is very sensitive to the inclusion threshold across the chosen number of iterations. Therefore, we ideally recommend use the GPT-4 model when reviewers have access to this model. Alternatively, reviewers must test the best and most efficient choice of inclusion probability on their test data.

Due to costs, we have not investigated the performance of GPT-4 with 10 iterations. As soon as the cost get close to the current cost of GPT-.3.5 models, users could considered screening all titles and abstracts with 10 iterations. For now suggest just to re-screening all references where humans and GPT disagree.

In contrast with priority screening methods (Hou & Tipton, 2024), the gpt models do have the potential to find more than 95% of the relevant study cf. FRIENDS.

A side-effect of this simulation was also to validate the performance of the AIscreenR software. Especially the use of function calling.

Student screening evaluation (Ng et al., 2014)

**6****TENTATIVE GUIDELINES**

*80% recall and 95% specificity.*

*Workflow and short package presentation*

* Testing, not training. Less is more.
* We show hierarchical screening can be conducted in the vignette following the AIscreenR package.
* When reviewers want to keep duplicate screening, we suggest that the GPT API models can be used as a third screener for extra insurance that all relevant studies are detected.
* How to set up the workflow presented in Table xx in R, can be found in the accompanied vignette to the AIscreenR package.
* In fact, we want to have specificity measure that does not equal 100 since we want the GPT model to enable us to double-check grayzone references so that we can be assured that we have not missed any relevant studies. Find what the human has potentially overlook.
* If the specificity is low, reviewers could work with the screening rule that all records that has been included by at least one screener enters the full-text screening.
* Start with testing whether using GPT is viable in a given reviews.

**Table x: Workflow for how to conduct TAB screening with GPT API models**

|  |  |
| --- | --- |
| **Step** | **Reviewer action** |
| 1 | Find a minimum of 10 relevant study records (ideally more). |
| 2 | Find a minimum of 190 irrelevant study records (ideally random sampled from the pool of records). |
| 3 | Construct the test dataset by combining the records from steps 1 and 2. |
| 4 | Develop one or multiple prompts and test the(ir) performance. |
| 5 | Repeat step 4 until reaching a recall close to 80% or more, and a specificity between 90-100%. If this step cannot be fulfilled, we recommend not to use the GPT API model as a second screener. Thus, human double screening is the ideal solution. Yet, the GPT API model can still be used as a third screener for an extra insurance of not missing any relevant studies. In cases where low budgets exclude human duplicate screening, we considered it fair to work with recall performances below 80% since the alternative (i.e., stand-alone single-screening) in these cases is worse. |
| 6 | Manually single screen all study records. If a GPT API model has shown to be a reliable second screener based on the text data, then this can be done by multiple reviewers/screeeners. |
| 7 | Run the TAB screening with the GPT API model. Consider removing all study records without an abstract and human screen those references. |
| 8 | Investigate and solve disagreements between the human and automated screening decisions. |

**Figure x: FIND NAME**

|  |  |
| --- | --- |
|  |  |

***5.1. When not to use GPT API model for TAB screening?***

**7 LIMITATIONS**

* Black box (but this does not only count for GPT this is often true for human screening as well)
* Different performance across model updates
* Function tech? We have no control over the existence of OpenAI
* Environmental impact (embrace the critiques from van Lissa). Combine with traditional machine learning and text-mining tools to reduce the number of records needed to be screened by the GPT API model
* Prizing
* Depends on available models
* Prompt sensitive
* Convient dataset used to construct the screening performance benchmark scheme.

**8 FUTURE RESEARCH**

* The use of hierarchical prompting in complex reviews. Simple prompts instead of long onces
* Evaluate Mistral which provides the possibility of locally downloading their model. This will overcome issues with deprecations and ensure reproducibility over time.
* Shiny app to ease user set-up challenges (O’Connor et al., 2019) to make the workflow more user-friendly.

**9 DISCUSSION**

* Talk about the interface here – cannot replicate the results on the ChatGPT interface
* Reviewers should not consider screening prioritization methods and GPT screening as two incommensurable methods. Instead, the strength from both should ideally be combined.
* Forces review times to make very narrow searches due to lack of ressources to conduct the title and abstract screening rigorously (Guo find in ICloud)
* We believe that the GPT-4 models will perform even better when fed with abstracts following a rigorous structure as in medicine.
* When not to use. If you cannot make the prompt work properly or if you screen very few studies.
* We believe that no automated tool should ever be at level 4 – there shall always be a human-in-the-loop to ensure adequate behavior the the screening tools. Consequently, GPT models used in non-systematic to reduce the number of studies needed to be screened should always include safety checks. For example, reviewers should randomly sample 5-10% of the studies excluded by GPT to test for serious flaws in its decision-making. If serious flaws are detected the reviewers must re-test the used prompt(s) or refrain from using the given GPT model.
* More rapid transfer of knowledge from review to policy, research, and practice
* Makes it possible to help to screen in extreme-sized reviews (Shemilt et al., 2014, 2016)
* Extra security in low-budget and/or time-limited projects where there is only access to a single screener.
* No need for unnecessary restriction on search string.
* To reduce the environmental impact and reduce the number of references needed to be screen. GPT API models could be used on a subset of studies, for example on all references not examined by humans after using priority screening.
* Future models should use seed to ensure reproducible screening. This is currently only available in the beta version but should be implemented in the software over time.
* Draw on ‘function call’ needs to be updated to work with tools.
* Requires continuous software development.

**ACKNOWLEDGEMENT**

Thanks to Jens Dietrichson, Trine Filges, Tiril Borge, Heather Melanie R. Ames, and Christopher James Rose for valuable comments and sharing of screening data. Also thanks to Sofie Elgaard Lisager Jensen, Johan Klejs, and Frederikke Lykke Witthöft Schytt for testing the AIscreenR software and for valuable inputs to the workflow.

**FUNDING STATEMENT**

This manuscript was funded by VIVE Campbell, Denmark

**DATA AVAILABILITY STATEMENT**

To adhere to the reproducibility framework proposed by Olorisade et al. (2017), replicate codes can be found at OSF [bit.ly/3spivoG](https://bit.ly/3spivoG):

**CONFLICT OF INTEREST STATEMENT**

The authors declare no conflict of interest.

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1. But already now, we see that in some applications of systematic reviews, the number of records needed to be screened way exceeds what can be considered an economically efficient and sustainable use of human resources, either due to very broad terms needed to be added to search string to cover all relevant studies (see e.g., Thomsen et al., 2022) or due to a broad aim of the review as is often the case with scoping review and evidence and gap maps (see e.g., Bondebjerg, Filges, et al., 2023). [↑](#footnote-ref-1)
2. To overcome/reduce this issue, a new tentative guideline termed SAFE has been developed in which it is suggested to use multiple machine learning algoritmes in order to detect all relevant references in the bulk of records (Boetje & van de Schoot, 2024). However, we do not considered this framework to have been thouroughly enough testing yet to know if the SAFE procedure allows reviewers to detect all relevant studies with the machine learning algoritms including in screening softwares such as ASReview. [↑](#footnote-ref-2)
3. We do not consider the level 4 of automation to be the ideal case since we consider human-in-the-loop operation to be state-of-the-art at the time of writing. [↑](#footnote-ref-3)
4. To our knowledge, GPT models has so far only be implemented in the EPPI Reviewer software with the aim to support automated data extraction from full texts (see EPPI-Centre, 2024) and not for TAB screening purposes. [↑](#footnote-ref-4)
5. This model has been deprecated [↑](#footnote-ref-5)
6. It is uncertain what exact model they authors used. We expect it to be the gpt-4-0613 API model. [↑](#footnote-ref-6)
7. Can be found at <https://github.com/mamishere/Article-Relevancy-Extraction-GPT3.5-Turbo> [↑](#footnote-ref-7)