

A Review of the Effectiveness of Three Main Types of Stress-Reduction Products

Jiayue Weng¹

¹ George School Bucks County, USA

Correspondence: Jiayue Weng, George School Bucks County, Pennsylvania, 18940, USA.

Received: October 14, 2025; Accepted: October 25, 2025; Published: October 27, 2025

Abstract

There is an increasing customer need for stress relief and promoting wellbeing, leading to many innovative stress relief products. Developers claim these products can reduce stress and boost well-being, but do they actually work? This study aims to examine how different products' effectiveness varies by demographic factors through three selected product categories that are associated with stress relief: Aromatherapy, fidget toys, and mindfulness apps. Research indicates relatively stronger effectiveness of direct inhalation aromatherapy and massage aromatherapy compared to indirect inhalation aromatherapy, while showing its potential as an effective placebo. Fidget toys tend to have low effectiveness in stress relief for typically developing students, but have shown effectiveness in decreasing activity level for students with attention difficulties. Mindfulness apps show higher effectiveness in stress alleviation for adolescents with higher levels of rumination, particularly when used in conjunction with longer or more frequent meditation sessions. Overall, current studies suggest that these products are generally effective, though specific contexts and demographics may make them more or less effective, making them suitable for different users' needs.

Keywords: stress relief, product effectiveness, demographic factors, placebo effect, user well-being, stress management

1. Introduction

In modern society, it is quite common to feel stressed out due to pressures from school or work, and self-reported stress continues to rise over recent years. In Webber's research (2024), nearly 2 in 5 (41%) of Americans report experiencing peak levels of stress. This is relevant not only in the United States, but globally. 62% of adults globally reported experiencing stress that affects their daily lives (Ipsos, 2024). High stress levels can influence both mental and physical health, leading to physical and emotional symptoms. The American Institute of Stress reports 77% of people feel their stress affects physical health, and 73% of people say their mental health is impacted (Liddell, 2025). Two-thirds (66%) of U.S. adults reported wanting more emotional support, and around a quarter (26%) of the adults reported needing a lot more support than they received currently (American Psychological Association, 2023). In short, managing stress seems to have become a common topic faced by the global population.

The amount of stress people experienced has led to an increasing interest in stress-reduction products. For instance, one report finds that 82% of U.S consumers consider wellness as their top or important priority in everyday lives (Callaghan et al., 2024), reflecting the growth potential of the wellness market. The high demand for such products has resulted in substantial expansion in the stress relief product market, with an annual growth rate projected to be 6.75% (Market Research Future, 2025). From scented pillow mist to fidget spinners and meditation apps, a variety of products have been created and sold in the market to help people feel relaxed.

Despite the popularity of stress-relief products worldwide, their actual effectiveness remains complex and inconsistent across studies. Existing research presents mixed findings - some studies highlight meaningful reductions in stress and anxiety, while others suggest limited or placebo-driven benefits. This inconsistency underscores the need to systematically review and compare different types of stress-relief products to determine which factors, including demographic and psychological characteristics, may influence their outcomes.

One of the main reasons people may be skeptical of stress-relief products is the placebo effect. The placebo effect is defined as an inert or innocuous medicine given to satisfy the patient (Margo, 1999). It simulates therapeutic changes to patients, but no biologically plausible explanation for the results (Margo, 1999). Despite interfering with experimental results, the placebo effect in stress relief products might not necessarily be something that diminishes product effectiveness. Although the benefits it produces doesn't come from the "real" product itself,

the effects due to expectancy and placebo effect can be real benefits experienced by the users. The placebo effect has value for users whose goal is to subjectively feel better.

This paper therefore focuses on three widely used stress-relieving modalities: aromatherapy, fidget toys, and mindfulness apps. Through a comprehensive review of existing literature, the paper aims to understand how effective these products are and if their effectiveness varies depending on user demographics. Because users often have specific objectives when choosing a stress relief product, this paper will assess product effectiveness in three dimensions: subjective experiences, productivity, and long-term effects to cover major user needs.

2. Aromatherapy

Imagine being greeted with a warm lavender-scented hand towel upon entering a spa. Its soothing aroma may quickly help you relax. This is one common example of how aromatherapy can be used in everyday life. Aromatherapy is defined as the systematic use of essential oils extracted from plants to support health and well-being (Hedigan et al., 2024). It is a form of complementary and alternative medicine (CAM) that functions as a complement to current mainstream medicine (Sánchez-Vidaña et al., 2017). Aromatherapy can be administered in many ways and can be mainly delivered in two forms: inhalation aromatherapy and aromatherapy massage. Inhalation aromatherapy can be further implemented in two ways: direct inhalation aromatherapy and indirect inhalation aromatherapy. Direct inhalation uses methods like individual inhalers, while indirect inhalation uses methods like room diffusers or bed spray. As aromatherapy grows in popularity, innovative aromatherapies are emerging by combining traditional aromatherapy with other products, such as body lotions and hand soap.

In general, studies show support for aromatherapy, especially when used for promoting relaxation, both subjectively and physiologically. On one hand, physiological measurements based studies supported aromatherapy's effectiveness. Furthermore, aromatherapy is tested to be effective in experimental contexts that are conducive to relaxation. This section will discuss the research evidence on the effectiveness of aromatherapy in detail and the relative effectiveness of aromatherapy submodalities compared to each other. In addition, this section will explore the potential use of aromatherapy in scented cosmetic products.

There is a good deal of supporting evidence for the effectiveness of aromatherapy in different settings and among a diverse age demographic. The systematic review by Hedigan et al. (2023) screened 76 published inhalation aromatherapy studies from 2000 to 2021 and concluded that over 70% of studies proved that aromatherapy interventions successfully reduced self-reported anxiety levels for patients in clinical settings. Moreover, in studies that involved physiological measures, 66% favoured aromatherapy over the control group (Hedigan et al., 2023). Other newly published studies further supported aromatherapy in reducing stress and anxiety in conditions other than clinical settings to help understand aromatherapy's effect in normal user's daily life. For example, a recent study by Guler et al. (2023) found that lavender oil-based aromatherapy can significantly help ease test anxiety and stress among nursing students. The intervention group, receiving indirect inhalation aromatherapy, self-reported a 20% decrease in tension compared to the control group (Guler et al., 2023). Mehrabian et al. (2022) found similar effects of aromatherapy on soothing anxiety among seniors. In their study with 38 elderly adults, the intervention group received 6 weeks of regular visits to 20-minute massage sessions combined with aromatherapy that uses lavender, chamomile, and rosemary oils. The self-reported data showed that anxiety has decreased by about 47% and depression has decreased by around 58% for the intervention group, whereas participants in the control group exhibited increased levels of anxiety and depression compared to baseline (Mehrabian et al., 2022). Another study by Hedigan et al. in 2024 proves the effectiveness of aromatherapy in both indirect inhalation using room diffusion and direct inhalation using aromasticks. 87.5% participants from the intervention group reported decreased levels of depression and 75% reported decreased levels of anxiety for indirect inhalation. Direct inhalation has shown similar results: there was a 24.16% increase in mean wellbeing score for the intervention group. The study showed effectiveness for both direct and indirect inhalation, proving the effectiveness of both modalities. Above studies supported the effectiveness for various types of aromatherapy among a diverse population, from young adults to seniors.

The effectiveness of aromatherapy sometimes varies by delivery method. Direct inhalation has been shown to reduce stress more effectively, whereas aromatherapy massage is particularly effective in alleviating depressive symptoms. Among various aromatherapeutic modalities, direct inhalation aromatherapy is considered more effective in reducing stress compared to indirect inhalation aromatherapy. A study done by Hedigan et al. (2024) shows increased self-reported wellbeing scores. The majority of participants improved from a low well-being score range to moderate or above, with 11% ultimately reporting high levels of well-being at the end of the follow-up experiment using direct inhalation aromatherapy. This conclusion is consistent with Cheong et al.'s finding (2021) favoring continuous inhalation over indirect inhalation in improving sleep problems. Similarly, a study from

Sánchez-Vidaña et al. (2017) explains the lack of effectiveness in certain aromatherapy studies can be attributed to the distance between the nostrils and the aroma. The longer distance between nose and scent can lead to decrease in effect, so indirect inhalation might be less effective compared to direct inhalation. In addition, aromatherapy massage is more effective than inhalation aromatherapy in alleviating depressive symptoms (Sánchez-Vidaña et al., 2017). Massage can reduce stress and promote wellbeing, which is evident through the decreased cortisol levels (Lake, 2018). When combined with aromatherapy, users can experience health benefits from both therapies, making it more effective than traditional methods (Sánchez-Vidaña et al., 2017).

Furthermore, when integrated with innovative scented products, aromatherapy continues to demonstrate measurable therapeutic benefits. A study by Springer et al. (2022) demonstrated the efficacy of scented cosmetic products in the reduction of stress among 25 healthy females, with a mean age of 25.7 years. The participants exhibited lower concentration cortisol levels, an increase in alpha brain waves, and decreased self-reported stress levels after using the product with active aromatherapy compounds. These findings suggest that aromatherapy can elicit both physiological and psychological stress reduction, supporting its effectiveness beyond mere placebo effects.

However, other studies have yielded more modest or inconsistent results, suggesting that the efficacy of aromatherapy may depend on context and methodology. A study by Chamine and Oken (2015) involving 81 adults found a limited effect of aromatherapy on stress reduction. Interestingly, participants who were aware of stress-reducing aroma showed slower reaction times in a stress-related task compared to those unaware of the aroma's purpose. This finding raises the possibility that expectancy or placebo effects contributed to perceived benefits. Nonetheless, several factors may explain these results without dismissing aromatherapy's potential effectiveness. The study exhibited a performance ceiling effect, as both groups made few errors on the task, suggesting the task lacked sufficient difficulty or variability to capture the subtle differences in stress responses. Moreover, contextual elements like the environment where the study was conducted likely played a role. Usually, aromatherapy is used to relax in calming environments like in the bedroom or spa settings, but this study tested its effectiveness during a quick task that required alertness rather than merely stress centered. This context requires more concentration and productivity, suggesting that aromatherapy might be more suitable for subjective relaxation rather than boosting productivity or concentration.

Taken together, these findings indicate that while aromatherapy can produce both physiological and psychological benefits, its effectiveness is highly context dependent. In addition, discrepancies and ambiguity in experimental setups and biases like demand characteristics and response bias may also contribute to inconsistent findings across studies. Furthermore, placebo effects play an important role in shaping observed outcomes in aromatherapy research.

Firstly, the ambiguity in scent types and the dosage of essential oil used in different studies have led to the conflicting results. For instance, the study conducted by Chamine and Oken (2015) does not state the precise weight of essential oil used and only describes it as "three drops" (p.2) of aroma solution. The vague language used to indicate dosage makes it difficult to assess and replicate results across studies due to the lack of consistency. Similarly, different types of essential oils used in studies may lead to potential differences in results. Essential oils extracted from plants might function differently due to their chemical compositions and extraction method, making it challenging to investigate the effectiveness of aromatherapy across various scents. Among various essential oils, lavender is a quintessential scent used in aromatherapy both in treatment and in research. Lavender accounts for 42% of the clinical trials testing aromatherapy during 2000 to 2021 on anxiety and stress in clinical settings (Hedigan et al., 2023). It is also the most used scent in studying aromatherapy's effect on sleep (Cheong et al., 2021). Within 34 studies analyzed by Cheong et al. (2021), 76% of the scent studied contained lavender in single or mixed aroma. They also found that the lavender inhalation showed the greatest effect among various single inhalation methods. Lavender's constant use in studies led to stronger supporting evidence in its effectiveness. In the future, a more homogeneous study method is recommended to prove the effectiveness of aromatherapy further.

In addition, potential biases like demand characteristics or response bias in research can cause the discrepancy in experimental results and conclusions in aromatherapy's effectiveness. Demand characteristics means cues or expectations that influence self-reported experiences of research participants (Whitehouse et al., 2002). For aromatherapy, participants can easily tell which experimental group they belong to. This might affect the research results, especially in studies that are solely based on self-report questionnaires. Participants might unintentionally report decreases in stress because they assume the aromatherapy will work, leading to a result in favor of the effectiveness of the aromatherapy. Similarly, response bias can potentially influence results. It happens when factors during the process of responding to surveys affect the way responses are provided, causing the results to deviate from the true value (Bogner & Landrock, 2016). For example, participants might assume the effects of

aromatherapy or that researchers want to find positive effects of aromatherapy, so they unconsciously respond in favor of aromatherapy in the self-reported questionnaires.

Some recent studies have adequately addressed potential bias critiqued above. These improved research designs have largely supported the effectiveness of aromatherapy. For example, a study conducted by Springer et al. (2022) perfumed both the intervention group and the control group with vanilla scent to ensure no perceivable differences in order to minimize the potential performance bias. Additionally, Springer et al. (2022) collected physiological data, such as brain waves, as evidence instead of solely relying on self-reported questionnaires to avoid response bias. With improved design, their studies showed significant benefits of aromatherapy in reducing stress. Similarly, Hedigan et al. (2024) scented the control group with a detectable aroma, preventing participants from telling which experimental group they were in, so that participants wouldn't change their behavior because of perceived differences. Participants of this study reported reduced levels of stress and anxiety, supporting aromatherapy as an effective means to reduce stress and anxiety.

Lastly, researchers found that the placebo effect may significantly contribute to effects in aromatherapy, but the contribution is beneficial to users regardless of experimental doubt. Masaoka et al. (2013) studied the effect of scent in aromatherapy and found more significant reduction in self-reported pain and unpleasantness scores when participants were informed about the benefits or noticed the lavender scent. The finding shows that the information about the scent and the scent itself both contributed to reduced perceptions of pain. The placebo effect in aromatherapy made researchers doubt the true effectiveness of aromatherapy, as experimental results might be inflated with placebo effect. However, from the user experience's perspective, even in situations when aromatherapy itself might not be as effective, it can still be utilized as a placebo and a cheaper alternative intervention for individuals struggling with chronic stress. A study by Chamine and Oken (2015) demonstrated the possibility that strong beliefs in the positive effect of aromatherapy might increase product performance, a finding that can be utilized in future aromatherapy product marketing. Subjective stress relief is an important objective for certain customers, so the placebo effect is still beneficial to the users. For a marketing perspective, the placebo effect can be utilized to further increase perceived effectiveness.

In summary, aromatherapy is generally effective in both self-report and physiological measures. The effectiveness of aromatherapy can vary based on its delivery method, with massage aromatherapy being most effective, followed by direct inhalation aromatherapy and indirect inhalation aromatherapy. To achieve a more substantial effect, users may opt for direct inhalation aromatherapy and massage aromatherapy, given they commit to a high number of sessions and a sufficient duration. From a research perspective, the varied experimental setups and existence of response bias may account for the opposing voices on the effectiveness of aromatherapy, whereas many recent studies that have addressed all factors discussed above were in favor of aromatherapy. To further validate the claim, new studies can be done with homogeneous study designs and the exact percentage dosage of essential oil. Furthermore, placebo effects inevitably play an important role in aromatherapy effectiveness, but it can be utilized in marketing to further improve user experience rather than being treated as inflating measured effectiveness.

3. Fidget Toys

While aromatherapy appeals to some users, others might want something more tangible. The history of fidget toys dates back to centuries of years ago, when worry beads were created by Greek monks on Mount Athos (Liu, 2025). The worry beads, also known as Komboloi, was first used for praying and mindfulness, but its function was later expanded into non-religious uses like decoration and relaxation. Similarly, other cultures have fidgets similar to worry beads, like small Baoding Balls for users to fidget with one hand and Kendama designed to increase focus and boost creativity (Liu, 2025). Today, we can see students subconsciously squeeze the stress ball as they listen to the lecture and some adults enjoy playing with something in their hand while having a business call. The long history of fidgeting suggests that humans might be naturally drawn to manipulating small objects as a way to release stress.

Fidget toys attempt to harness our natural tendency to fidget when we are feeling anxious through creating a specific object to fidget with. From fidget spinners to squishy stress balls and fidget cubes, tactile sensory input is designed with the aim of enhancing concentration, relieving stress and even improving working and academic performance. The global fidget toys market reached 1798 million in sales revenue in 2025, with projections of an 8.21% growth rate, reaching 3380.09 million as of 2033 (Singh, 2025). The growing market reflected the interest for such products. Propelling such a high market growth is the marking of this product to corporate and educational environments. In school settings, fidget toys are used to help focus on attention and classroom, while it is used in alleviating stress and increasing focus during meetings. Advertisers claim that fidget toys can be aides for

individuals with anxiety, autism spectrum disorders (ASD) and attention-deficit hyperactivity disorder (ADHD), while promising greater concentration and improving creativity (Pappas, 2017).

Empirical evidence offers practical support for these claims, suggesting that the values of fidget toys may extend beyond the placebo effect for certain users and contexts. Accordingly, the following section discusses their effectiveness in improving on-task behavior across different user demographics and activity types to identify populations most likely to benefit. Moreover, the section will also explore how future product design changes might further enhance their functionality and stress-relief potential.

In general, studies show support for fidget toys in increasing on task behavior for children and adults with neurodivergence such as ADHD and ASD. ADHD and ASD are two of the most common neurodevelopmental disorders with an estimated prevalence rate of 11.4% among children and adolescents (Scandurra et al., 2019; Data and Statistics on ADHD, 2024). People diagnosed with ADHD and ASD often experience symptoms such as inattention, hyperactivity and impulsivity, with impaired motor coordination problems observed in one third of children with ADHD (Fliers et al., 2008) and delayed sensory processing developments (Shimizu et al, 2014). Fidget toys such as spinners can be beneficial for children with neurodivergence through aiding developments in fine motor control and sensory processing (Liu, 2025).

Experimental results provide strong support on fidget toy's effectiveness for people with ADHD. A variety form of fidget toys has been proven to be effective in increasing on-task behavior of children with ADHD, such as the fidget spinner (Aspiranti and Hulac, 2021), handheld manipulator, and rubber band for feet use (Mathews et al., 2020). Aspiranti and Hulac (2021) found a 45% immediate increase in on-task behavior for second-grade students with ADHD when the fidget spinner was implemented, highlighting itseffectiveness and potential as a simple classroom aid. Similarly, a study done by Mathews et al. (2020) found similar effects with ABAB withdrawal design where fidget toys were introduced twice to validate the toys' effectiveness. The study showed a 45-55% overall attention gain among students, showing significant effect of fidget toys for students with ADHD. Moreover, a study conducted by Son et al. (2024) found that fidgeting may aid in sustained attention during the attention-demanding, cognitive control processes for adults with ADHD. This result shows that neurodivergent adults also enjoy fidget toy effectiveness.

Benefits of fidget toys have also been found among autistic children. Roche et al. (2023) studied the effect of fidget toys among 53 autistic children and 76 neurotypical children. Their study found over 68% parents of autistic children reporting fidget toys to be beneficial for their children. 40% more parents of autistic children, compared to that of neurotypical children, reported reductions in their children's f anxiety levels associated with fidget toy use. The effectiveness of fidget toys for autistic children appears to be related to the act of fidgeting itself. Neurodivergent individuals - particularly those with ASD or ADHD - might benefit more from fidget toys because fidgeting serves as a self-regulatory behavior. A study conducted by Grodner's (2015) found significant correlation between frequent fidgeting behavior and improved task performance on the Stroop task when participants engaged with a fidget toy. Furthermore, stimming, also known as repetitive movements, is a common characteristic of autism. Kapp et al. (2019), through interviews with 32 autistic adults, identified stimming as a key self-regulatory mechanism for emotional and sensory modulation. Because fidgeting behavior is one of core characteristics of both ASD and ADHD (Martinez et al., 2024), fidget toys may effectively support neurodivergent individuals by providing a structured and socially acceptable outlet for their self-regulation.

On the other hand, studies involving neurotypical young adults report limited benefits from fidget toys, suggesting their effectiveness may depend on task difficulty and user characteristics. Kriescher (2020) found no significant improvements in task performances from the use of fidget spinner or stress ball among 66 college students. Task performance measures - including Stroop tasks measuring attention and inhibition, reading comprehension, listening comprehension, and working memory and comprehension tasks - showed no meaningful differences between intervention and control groups. Similarly, a study by Sadri and Moodithaya (2021) found that neither slime nor fidget spinners significantly reduced acute stress among students aged 18 to 22 years old, with no significant difference in heart rate variability, showing no physiological benefit. Interestingly, Grodner (2015) found a significant improvement in task performance using the same test as that of Kriescher (2020)'s, but with an easier version with less amount of cognitive resources. This seems to suggest that the effectiveness of fidget toys may vary with task complexity - they may enhance performance and focus during simpler, less cognitively demanding tasks, but not when high levels of concentration or cognitive load are required.

Similar to aromatherapy, the placebo effect and demand characteristics influence fidget toy effectiveness. The simplicity of using fidget toys further contributes to its wide appeal to parents, as this intervention brings quick response through letting their child engage with a toy. While skeptics argue that the observed benefits may stem

largely from placebo effects, it is important to recognize that placebo responses can still enhance the perceived well-being and focus, thereby amplifying the overall effectiveness of fidget toys. As discussed earlier, the placebo effect does not necessarily invalidate a product's utility; rather, it can serve as a psychological mechanism that reinforces positive outcomes. Additionally, demand characteristics also affect tested effectiveness as instructions given to the participants might impact tested effectiveness. As mentioned previously in the aromatherapy section, demand characteristic refers to cues or expectations that influence study results (Whitehouse et al., 2002). For instance, Grodner (2015) found that university students from the activation team, who were told that playing with a fidget toy improves cognitive test performance did better in the Stroop task, an attention and inhibition task, than other groups that received different instructions.

Moreover, studies also found the design features of fidget toys can influence their success. According to Roche et al. (2023), the bright color and noise generated with a fidget spinner might distract children from being focused therefore may account for its ineffective results. To have a more effective product, future designs can focus on fidgeting and tactile designs, instead of adding visual designs that interfere with its main effect.

In summary, fidget toys are proven to be effective in improving task performance and attention among neurodivergent children, but are less effective among neurotypical adults with cognitively demanding tasks. Similar to aromatherapy, placebo effect in fidget toys can be used to increase subjective benefits. Moreover, design features may hinder effectiveness, a finding that can be utilized in future product designs to prevent distractions. Future fidget toys may have more emphasis on tactile designs and try to eliminate sensory designs that attract attention, especially when its main audiences are children that are easily distracted. Instruction given also affects effectiveness, with the potential of using product instructions to achieve better results.

4. Mindfulness Apps

Some people may prefer to turn to their phones for support from apps when feeling stressed or anxious. Imagine feeling anxious at night and opening the mindfulness app on your phone for a quick wellness boost. A calm voice guides you through a slow breathing exercise or a meditation, with soothing music in the background. Made more advanced with growing technology, mindfulness apps prove an accessible digital pathway to stress relief. Mindfulness is defined as "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally" (Kabat-Zinn, 1994, p.4). Mindfulness is nurturing greater awareness and acceptance towards the present moment (Kabat-Zinn, 1994) and is theorized to increase subjective well-being, reduce psychological symptoms, and improve behavioral regulation (Keng et al., 2011). A mindfulness-based app was created for the purpose of facilitating mindfulness practice (Macrynikola et al., 2024).

Main features of mindfulness-based mobile applications include meditation practice, mindfulness training, assessments or tests, attention focus and mixed objectives (Plaza et al., 2013). 59% of those mindfulness applications are focused on mediation practices (Plaza et al., 2013). The most common health conditions targeted by these applications are stress, followed by mental health and depression (Muhiyaddin et al., 2022). Mindfulness apps became increasingly popular during the COVID-19 pandemic. Google reported that searches for yoga and meditation apps increased by 65% between 2019 and 2020 (Goodwin, 2020). The increasing interest resulted in leading applications like Headspace receiving approximately one million downloads worldwide (Ceci, 2025).

This section focuses on populations with the greatest access to and engagement with mindfulness applications: namely, adolescents, young adults and working professionals. In general, studies have shown strong support for mindfulness apps in alleviating stress and increasing well-being, especially with long-term uses. The following section discusses the effect of mindfulness-based apps in alleviating stress and increasing well-being across different age demographics. With that, this study will draw conclusions on the user demographics that will be most benefited by mindfulness apps and determine how users can enjoy long-term benefits from using this product.

Mindfulness apps are found to be effective among young adults in increasing well-being and reducing stress by systematic reviews, small pilot studies and larger sample studies. Systematic review by Schwartz et al. (2023) screened 28 studies that used different well-being measures, apps, and intervention duration. Their review concluded that 68% of studies reported positive effects of mindfulness apps on at least one aspect of well-being. 21% of these studies reported significant improvements in mental well-being, further validating its effectiveness. Additionally, Huberty et al. (2019) found a positive effect of mindfulness apps in reducing perceived stress, increasing mindfulness and self-compassion in 88 college students. The study found the treatment group experiences over 20% more reduction in stress and total mindfulness score, together with around 24% increase in self-compassion compared to the control group, showing moderate to large effect for mindfulness apps. A study by Lahtinen et al. (2023) found a similar effect on a larger scale with 561 university students. The treatment group

had shown more reduction in depression and stress over the active control group, showing that the tested effectiveness is more than just placebo effect.

Among teenagers, mindfulness apps are found to be particularly effective for adolescents with higher levels of rumination. Webb et al. (2022) conducted a study with 152 adolescents, assigning participants to either an app-based mindfulness training program or a mood monitoring control condition. The findings indicated that mindfulness apps-based training led to significant reductions in rumination, especially among adolescents with elevated traits of rumination. Notably, the intervention was more effective in reducing problem-focused rumination than emotion-focused rumination. These results imply that mindfulness apps may be more beneficial for adolescents predisposed to cognitive over-engagement and internalized stress responses. The long-term importance of these findings is underscored by Abela and Hankin's (2011) longitudinal study, which demonstrated that higher levels of rumination in adolescents were associated with a greater likelihood of future major depressive episodes and greater duration of these episodes. Taken together, this demonstrates the preventative potential of mindfulness apps in supporting adolescent mental health by reducing maladaptive rumination and lowering the risk of developing chronic depressive symptoms.

Mindfulness apps also were found effective in workplaces. Study done by Huberty et al. (2022) found significant improvements in depression, anxiety and stress among 192 employees after 8 weeks of using mindfulness apps. For example, compared to the waitlist control, the intervention group had an overall 9.48% decrease in stress and 7.88% decrease in depression. Additionally, the study found the app's ability to improve insomnia and boost productivity in work. Similarly, literature review by Egger et al. (2023) found effectiveness in decreasing stress-related symptoms related to work in all 19 products being studied. This strongly supports the general effectiveness of mindfulness applications in helping with stress management at work, making it an attractive alternative to face-to-face interventions.

Among mindfulness application users, more effectiveness was shown in users with longer periods of consistent practice and longer practice time. As articulated by Kabat-Zinn (2003), mindfulness practice develops over time and regulated practice is needed to achieve better effectiveness. This general theory on practicing mindfulness is being specifically validated for experimental studies focused on mindfulness applications. A study by Yoon et al. (2022) demonstrated the long-term effect of mindfulness training in increasing emotional regulation. Additionally, a study conducted by Pierce et al. (2024) found time spent on mindfulness apps is associated with decreased anxiety, showing that both long-term regular practice and duration of practice time affects its effectiveness.

Even shorter periods of using mindfulness applications can result in long term benefits. A study by Keng et al. (2022) found increasing professional quality of life from healthcare works even after brief periods of mindfulness practice, revealing the application's uniqueness compared to two previous products. Unlike aromatherapy and fidget toys, whose effect focuses more on immediate, short-term reliefs, the effectiveness of mindfulness applications extends to longer periods when users are no longer using this product.

Doubts on the effectiveness of mindfulness apps are mainly focused on high attrition bias and potential placebo effect.

Attrition bias is a major bias for mindfulness apps, raising doubt of whether mindfulness apps are actually effective. Attrition in mindfulness app studies have been high: Schwartz et al. (2023) found around 23.4% median attention rates among studies that tested effects of mindfulness apps on well-being. Attrition bias is a type of selection bias that occurs due to systematic differences between study groups in number and ways participants are lost from a study (Nunan et al., 2018). For example, participants who found mindfulness apps are less effective are more likely to drop out of the study, leading to overestimation of the app's effectiveness based on collected results. When compared with previous products like aromatherapy and fidget toys, mindfulness apps have a higher attrition rate because it requires higher time commitment from participants. Studies often require participants to actively use the app for several weeks, so it is easy for groups to drop out.

However, other effectiveness studies with low attrition provide strong evidence in support of mindfulness apps. A study by Lindsay et al. (2019) concluded positive effects in mindfulness interventions for increasing positive emotions in daily life with only 2% participant drop-out rate and no condition differences in study drop-outs. 153 stressed adults experienced increased positive feelings only after receiving 2 weeks of mindfulness training, proving the value of smartphone-based mindfulness interventions for participants hoping to receive mindfulness training. Similarly, a study by Yoon et al. (2022) found participants receiving mobile mindfulness training to experience a significant increase in subjective well-being compared to the wait-list control group. Among 45 employees, 22 of them who received the mobile mindfulness training also experienced reduced negative emotional symptoms and maintained improvements at follow-up in the fourth week post-intervention. Only 1 participant was

lost from the control group during this study, preventing its results from being influenced by the attrition bias. These two studies with low attrition show that attrition bias is not likely to be a major influence in other study results.

The opposing researchers also argued that the placebo effect significantly contributes to the effectiveness in mindfulness apps. A study conducted by Davies et al. (2023) tested the placebo effect in mindfulness apps. The study compared online mindfulness intervention effectiveness with specific sham mindfulness sessions, general sham mindfulness sessions and audiobook control. Results found no significant differences between online mindfulness to the shams in reducing pain or unpleasantness among 169 adults with chronic or recurrent pain. But still, from the user experience perspective, placebo effect can add on to perceived effectiveness, making mindfulness apps an accessible alternative. Moreover, even though no significant difference has been found within the app and both shams, all of these groups have shown reduced pain unpleasantness relative to audiobook control. This proves that regardless of placebo effect or not, mindfulness apps can reduce subjective unpleasantness. Moreover, the study only focuses on single session effectiveness in reducing chronic pain unpleasantness, while mindfulness apps are usually used on a routine basis. The number and frequency of mindfulness sessions may be another reason why there are no significant differences in results.

In summary, mindfulness apps are proven to be effective for increasing subjective well-being, mindfulness and self-compassion and reducing perceived stress. Although scholars have raised concerns about potential high attrition bias and placebo effect in mobile-based mindfulness interventions, studies have adequately responded to these doubts by minimizing attrition rates and still demonstrated the effectiveness of mindfulness apps. Furthermore, mindfulness apps showed long-term benefits for users post-intervention, making it a good product for users seeking long-term benefits in addition to quick benefits from single sessions.

5. Conclusion

Effectiveness of these three products discussed above varied by user demographic and needs. Overall, aromatherapy demonstrated high effectiveness in improving user's subjective experiences, fidget toys might help with productivity in populations with additional needs, and mindfulness apps might help with sustaining long-term effects.

Placebo effect occurs among all three stress relief products and can be utilized to provide increased subjective stress relief experience for users. Although the placebo effect is often regarded as a methodological limit that complicates the interpretation of experimental results, this paper argues that it also represents an effective psychological mechanism capable of producing psychological and physiological relief. Therefore, rather than dismissing the placebo effect as a source of bias, marketing strategies may consider amplifying customer perceived benefits by shaping users' expectations through strategic design and marketing.

Aromatherapy is generally effective under conditions for all user demographics, from young adults to seniors. Although age demographics are likely not a determining factor for aromatherapy's effectiveness, submodalities of aromatherapy do. Aromatherapy is most effective for subjective stress relief when using massage aromatherapy and direct inhalation aromatherapy, whereas indirect inhalation aromatherapy is less effective. Studies also suggest aromatherapy's potential to be combined with other products, for example, scented cosmetics. In this case, aromatherapy can become easily accessible for users as part of their daily life. Such adoption can boost the effectiveness of aromatherapy since positive results are often associated with a higher number of sessions and longer exposure times (Sánchez-Vidaña et al., 2017). By incorporating aromatherapy into users' existing routines, it becomes easier to use frequently, leading to better effects.

Fidget toys are generally effective for increasing attention among neurodivergent children and adults. It is most effective in improving task performance and attention among neurodivergent children because it aids developments in fine motor control and serves as a socially acceptable outlet for their fidgeting behavioral tendency. Although task difficulty makes fidget toys less effective among adults, fidget toys still show subjective effectiveness among neurodivergent adults. Compared to the other two products, fidget toys showed stronger effectiveness in increasing on-task behavior and thus improved task performance. To further increase effectiveness, future product designs can focus on tactile designs and prevent distractions from sensory designs.

Mindfulness Apps are found to be generally effective among all age demographics, from young adults to employees in workspaces. It is most effective among teenagers with higher traits of rumination, highlighting mindfulness applications in preventing and decreasing depressive episodes. Duration of application usage tends to be the deciding factor in its effectiveness. To receive higher effectiveness from mindfulness apps, users may have longer periods of consistent practice and longer practice time. While shorter periods of practice might be less

effective, it does also result in long term benefits even post-intervention. Unlike the other two products, mindfulness apps provide users with long-term effectiveness.

In conclusion, the current review highlights that while all three products - aromatherapy, fidget toys and mindfulness apps - offer meaningful benefits, their effectiveness is context-dependent and influenced by user characteristics, application mode, and expectancy effects. Together, these findings suggest that stress management is best achieved through personalized approaches that align with users' sensory preferences, behavioral tendencies and technological accessibility. Future research should continue to investigate how combining these interventions and leveraging psychological mechanisms, such as the placebo effect, may lead to more comprehensive and sustainable stress.

References

- [1] Abela, J. R., & Hankin, B. L. (2011). Rumination as a vulnerability factor to depression during the transition from early to middle adolescence: A multiwave longitudinal study. *Journal of Abnormal Psychology, 120*(2), 259–271. <https://doi.org/10.1037/a0022796>
- [2] American Psychological Association. (2023). *Stress in America 2023: A nation recovering from collective trauma*. <https://www.apa.org/news/press/releases/stress/2023/collective-trauma-recovery>
- [3] Aspiranti, K. B., & Hulac, D. M. (2021). Using fidget spinners to improve on-task classroom behavior for students with ADHD. *Behavior Analysis in Practice, 15*(2), 454–465. <https://doi.org/10.1007/s40617-021-00588-2>
- [4] Bogner, K., & Landrock, U. (2016). *Response biases in standardised surveys*. GESIS – Leibniz Institute for the Social Sciences. https://doi.org/10.15465/gesis-sg_en_016
- [5] Callaghan, S., Doner, H., Medalsy, J., Pione, A., & Teichner, W. (2024, January 16). *The trends defining the \$1.8 trillion global wellness market in 2024*. McKinsey & Company. <https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/the-trends-defining-the-1-point-8-trillion-dollar-global-wellness-market-in-2024>
- [6] Ceci, L. (2025, March 5). *Leading health and meditation apps worldwide in January 2025, by downloads*. Statista. <https://www.statista.com/statistics/1239640/top-health-and-meditation-apps-monthly-downloads/>
- [7] Centers for Disease Control and Prevention. (2024, November 19). *Data and statistics on ADHD*. <https://www.cdc.gov/adhd/data/index.html>
- [8] Chamine, I., & Oken, B. S. (2015). Expectancy of stress-reducing aromatherapy effect and performance on a stress-sensitive cognitive task. *Evidence-Based Complementary and Alternative Medicine: eCAM, 2015*, Article 419812. <https://doi.org/10.1155/2015/419812>
- [9] Cheong, M. J., Kim, S., Kim, J. S., Lee, H., Lyu, Y. S., Lee, Y. R., Jeon, B., & Kang, H. W. (2021). A systematic literature review and meta-analysis of the clinical effects of aroma inhalation therapy on sleep problems. *Medicine, 100*(9), Article e24652. <https://doi.org/10.1097/MD.00000000000024652>
- [10] Davies, J. N., Colagiuri, B., Sharpe, L., & Day, M. A. (2023). Placebo effects contribute to brief online mindfulness interventions for chronic pain: Results from an online randomized sham-controlled trial. *Pain, 164*(10), 2273–2284. <https://doi.org/10.1097/j.pain.0000000000002928>
- [11] Egger, S. M., Frey, S., Sauerzopf, L., & Meidert, U. (2023). A literature review to identify effective web- and app-based mHealth interventions for stress management at work. *Workplace Health & Safety, 71*(10), 452–463. <https://doi.org/10.1177/21650799231170872>
- [12] Fliers, E., Rommelse, N., Vermeulen, S. H., Altink, M., Buschgens, C. J., Faraone, S. V., Sergeant, J. A., Franke, B., & Buitelaar, J. K. (2008). Motor coordination problems in children and adolescents with ADHD rated by parents and teachers: Effects of age and gender. *Journal of Neural Transmission (Vienna, Austria : 1996), 115*(2), 211–220. <https://doi.org/10.1007/s00702-007-0827-0>
- [13] Goodwin, J. (2020, March 25). *Health and wellness apps offer free services to help those coping with coronavirus*. USA Today. <https://www.usatoday.com/story/tech/2020/03/21/health-and-wellness-apps-offer-freebies-coping-coronavirus/2892085001/>
- [14] Grodner, K. (2015). *To fidget or not to fidget: The effect of movement on cognition* [Master's thesis, Nova Southeastern University]. ProQuest Dissertations Publishing.
- [15] Guler, S., Demir, G., & Sahan, S. (2023). The effect of aromatherapy performed to nursing students on the level of test-taking anxiety and academic achievement. *International Journal of Caring Sciences, 16*(3),

- 1728–1736.
- [16] Hedigan, F., Sagheri, D., Sheridan, H., & Sasse, A. (2024). Investigation of the impact of inhalation aromatherapy on relaxation and wellbeing in a young adult population. *Current Research in Complementary & Alternative Medicine*, 8(2). <https://doi.org/10.29011/2577-2201.100254>
- [17] Hedigan, F., Sheridan, H., & Sasse, A. (2023). Benefit of inhalation aromatherapy as a complementary treatment for stress and anxiety in a clinical setting - A systematic review. *Complementary Therapies in Clinical Practice*, 52, Article 101750. <https://doi.org/10.1016/j.ctcp.2023.101750>
- [18] Huberty, J. L., Espel-Huynh, H. M., Neher, T. L., & Puzia, M. E. (2022). Testing the pragmatic effectiveness of a consumer-based mindfulness mobile app in the workplace: Randomized controlled trial. *JMIR mHealth and uHealth*, 10(9). <https://doi.org/10.2196/38903>
- [19] Ipsos. (2024, October 8). *Ipsos World Mental Health Day report*. <https://www.ipsos.com/en-us/ipsos-world-mental-health-day-report>
- [20] Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice*, 10(2), 144–156. <https://doi.org/10.1093/clipsy.bpg016>
- [21] Kapp, S. K., Steward, R., Crane, L., Elliott, D., Elphick, C., Pellicano, E., & Russell, G. (2019). 'People should be allowed to do what they like': Autistic adults' views and experiences of stimming. *Autism: The International Journal of Research and Practice*, 23(7), 1782–1792. <https://doi.org/10.1177/1362361319829628>
- [22] Keng, S. L., Smoski, M. J., & Robins, C. J. (2011). Effects of mindfulness on psychological health: A review of empirical studies. *Clinical Psychology Review*, 31(6), 1041–1056. <https://doi.org/10.1016/j.cpr.2011.04.006>
- [23] Kriescher, S. L. (2020). *The effects of fidgets on attention and learning of college students* [Doctoral dissertation, University of Northern Colorado]. UNCO Digital Scholarship. <https://digscholarship.unco.edu/dissertations/666>
- [24] Lahtinen, O., Aaltonen, J., Kaakinen, J., Franklin, L., & Hyönä, J. (2023). The effects of app-based mindfulness practice on the well-being of university students and staff. *Current Psychology (New Brunswick, N.J.)*, 42(6), 4412–4421. <https://doi.org/10.1007/s12144-021-01762-z>
- [25] Lake, J. (2018, October 19). *Regular massages can significantly reduce stress and anxiety*. Psychology Today. <https://www.psychologytoday.com/us/blog/integrative-mental-health-care/201810/massage-therapy-anxiety-and-stress>
- [26] Li, H., Zhao, M., Shi, Y., Xing, Z., Li, Y., Wang, S., Ying, J., Zhang, M., & Sun, J. (2019). The effectiveness of aromatherapy and massage on stress management in nurses: A systematic review. *Journal of Clinical Nursing*, 28(3-4), 372–385. <https://doi.org/10.1111/jocn.14596>
- [27] Liddell, D. (2025, April 21). *Stress awareness*. The American Institute of Stress. <https://www.stress.org/news/stress-awareness/>
- [28] Lindsay, E. K., Young, S., Brown, K. W., Smyth, J. M., & Creswell, J. D. (2019). Mindfulness training reduces loneliness and increases social contact in a randomized controlled trial. *Proceedings of the National Academy of Sciences of the United States of America*, 116(9), 3488–3493. <https://doi.org/10.1073/pnas.1813588116>
- [29] Liu, Y. (2025). The rise of sensory fidget toys: Origins, psychological principles, and their role in stress relief and mental health. *SHS Web of Conferences*, 213, Article 02027. <https://doi.org/10.1051/shsconf/202521302027>
- [30] Macrynika, N., Mir, Z., Gopal, T., Rodriguez, E., Li, S., Cox, M., Yeh, G., & Torous, J. (2024). The impact of mindfulness apps on psychological processes of change: A systematic review. *Npj Mental Health Research*, 3(1), Article 14. <https://doi.org/10.1038/s44184-023-00048-5>
- [31] Margo, C. E. (1999). The placebo effect. *Survey of Ophthalmology*, 44(1), 31–44. [https://doi.org/10.1016/s0039-6257\(99\)00060-0](https://doi.org/10.1016/s0039-6257(99)00060-0)
- [32] Market Research Future. (2025). *Stress relief supplements market*. <https://www.marketresearchfuture.com/reports/stress-relief-supplements-market-10640>
- [33] Martinez, S., Stoyanov, K., & Carcache, L. (2024). Unraveling the spectrum: Overlap, distinctions, and nuances of ADHD and ASD in children. *Frontiers in Psychiatry*, 15, Article 1387179.

- <https://doi.org/10.3389/fpsy.2024.1387179>
- [34] Masaoka, Y., Takayama, M., Yajima, H., Kawase, A., Takakura, N., & Homma, I. (2013). Analgesia is enhanced by providing information regarding good outcomes associated with an odor: Placebo effects in aromatherapy? *Evidence-Based Complementary and Alternative Medicine: eCAM*, 2013, Article 921802. <https://doi.org/10.1155/2013/921802>
- [35] Mehrabian, S., Tirgari, B., Forouzi, M. A., Tajadini, H., & Jahani, Y. (2022). Effect of aromatherapy massage on depression and anxiety of elderly adults: A randomized controlled trial. *International Journal of Therapeutic Massage & Bodywork*, 15(1), 37–45. <https://doi.org/10.3822/ijtmb.v15i1.645>
- [36] Muhiyaddin, R., Abd-Alrazaq, A., Alajlani, M., Shah, Z., Alam, T., & Househ, M. (2022). Features of meditation apps: A scoping review. *Studies in Health Technology and Informatics*. <https://doi.org/10.3233/shti210938>
- [37] Nunan, D., Aronson, J., & Bankhead, C. (2018). Catalogue of bias: Attrition bias. *BMJ Evidence-Based Medicine*, 23(1), 21–22. <https://doi.org/10.1136/ebmed-2017-110883>
- [38] Oswald, D., Sherratt, F., & Smith, S. (2014). Handling the Hawthorne effect: The challenges surrounding a participant observer. *Review of Social Studies*, 1(1), 53–73. <https://doi.org/10.21586/ross0000004>
- [39] Pappas, S. (2017). *Fidget spinners: What they are, how they work and why the controversy*. Live Science. <https://www.livescience.com/58916-fidget-spinner-faq.html>
- [40] Phillips, M. R., Kaiser, P., Thabane, L., Bhandari, M., Chaudhary, V., & Retina Evidence Trials InterNational Alliance (R.E.T.I.N.A.) Study Group. (2022). Risk of bias: Why measure it, and how? *Eye (London, England)*, 36(2), 346–348. <https://doi.org/10.1038/s41433-021-01759-9>
- [41] Piao, X., Xie, J., & Managi, S. (2024). Continuous worsening of population emotional stress globally: Universality and variations. *BMC Public Health*, 24, Article 3576. <https://doi.org/10.1186/s12889-024-20961-4>
- [42] Pierce, M. E., Mirabito, G., & Verhaeghen, P. (2024). Mind the app: More time spent on headspace leads to beneficial day-to-day changes in mindfulness, depression, anxiety and stress in college students. *Cogent Mental Health*, 3(1). <https://doi.org/10.1080/28324765.2024.2400878>
- [43] Plaza, I., Demarzo, M. M., Herrera-Mercadal, P., & García-Campayo, J. (2013). Mindfulness-based mobile applications: Literature review and analysis of current features. *JMIR mHealth and uHealth*, 1(2), Article e24. <https://doi.org/10.2196/mhealth.2733>
- [44] Roche, M. A., Back, E., & Van Herwegen, J. (2024). Parental perspectives on the use of fidget toys and sensory-seeking profiles in autistic and neurotypical children. *Current Psychology: A Journal for Diverse Perspectives on Diverse Psychological Issues*, 43(17), 15872–15882. <https://doi.org/10.1007/s12144-023-05483-3>
- [45] Sadri, H., & Moodithaya, S. S. (2021). Effectiveness of toys in relieving acute stress measured by heart rate variability in young adults. *International Journal of Current Research and Review*, 13(02), 33–38. <https://doi.org/10.31782/ijcrr.2021.13207>
- [46] Scandurra, V., Emberti Gialloreti, L., Barbanera, F., Scordo, M. R., Pierini, A., & Canitano, R. (2019). Neurodevelopmental disorders and adaptive functions: A study of children with Autism Spectrum Disorders (ASD) and/or Attention Deficit and Hyperactivity Disorder (ADHD). *Frontiers in Psychiatry*, 10, Article 673. <https://doi.org/10.3389/fpsy.2019.00673>
- [47] Schwartz, K., Ganster, F. M., & Tran, U. S. (2023). Mindfulness-based mobile apps and their impact on well-being in nonclinical populations: Systematic review of randomized controlled trials. *Journal of Medical Internet Research*, 25, Article e44638. <https://doi.org/10.2196/44638>
- [48] Shimizu, V. T., Bueno, O. F., & Miranda, M. C. (2014). Sensory processing abilities of children with ADHD. *Brazilian Journal of Physical Therapy*, 18(4), 343–352. <https://doi.org/10.1590/bjpt-rbf.2014.0043>
- [49] Singh, S. (2025, August 13). *Fidget toys market report 2025 (global edition)*. Cognitive Market Research. <https://www.cognitivemarketresearch.com/fidget-toys-market-report>
- [50] Son, H. M., Calub, C. A., Fan, B., Dixon, J. F., Rezaei, S., Borden, J., Schweitzer, J. B., & Liu, X. (2024). A quantitative analysis of fidgeting in ADHD and its relation to performance and sustained attention on a cognitive task. *Frontiers in Psychiatry*, 15, Article 1394096. <https://doi.org/10.3389/fpsy.2024.1394096>

- [51] Springer, A., Höckmeier, L., Schicker, D., Hettwer, S., & Freiherr, J. (2022). Measurement of stress relief during scented cosmetic product application using a mood questionnaire, stress hormone levels and brain activation. *Cosmetics*, 9(5), Article 97. <https://doi.org/10.3390/cosmetics9050097>
- [52] Sánchez-Vidaña, D. I., Ngai, S. P., He, W., Chow, J. K., Lau, B. W., & Tsang, H. W. (2017). The effectiveness of aromatherapy for depressive symptoms: A systematic review. *Evidence-Based Complementary and Alternative Medicine*, 2017, Article 5869315. <https://doi.org/10.1155/2017/5869315>
- [53] Webb, C. A., Swords, C. M., Lawrence, H. R., & Hilt, L. M. (2022). Which adolescents are well-suited to app-based mindfulness training? A randomized clinical trial and data-driven approach for personalized recommendations. *Journal of Consulting and Clinical Psychology*, 90(9), 655–669. <https://doi.org/10.1037/ccp0000763>
- [54] Webber, T. J. (2024, September 24). *America is becoming stressed to the max*. WorldHealth.net. <https://worldhealth.net/news/america-is-becoming-stressed-to-the-max/>
- [55] Whitehouse, W. G., Orne, E. C., & Dinges, D. F. (2002). Demand characteristics: Toward an understanding of their meaning and application in clinical practice. *Prevention & Treatment*, 5(1). <https://doi.org/10.1037/1522-3736.5.1.534i>
- [56] Yoon, S. I., Lee, S. I., Suh, H. W., Chung, S. Y., & Kim, J. W. (2022). Effects of mobile mindfulness training on mental health of employees: A CONSORT-compliant pilot randomized controlled trial. *Medicine*, 101(35), Article e30260. <https://doi.org/10.1097/MD.00000000000030260>

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).