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REVIEW ARTICLE

Behavioral economics enhancers

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Abstract
Recent meta-analyses suggest that certain drugs act as cognitive enhancers and can increase attentional investment and performance even for healthy adults. The current review examines the potential of behavioral economics enhancers (BEEs) for similarly improving cognitive performance and judgments. Traditionally, behavioral economics theory has adopted a skeptical approach regarding the notion of whether individuals can overcome judgment biases through variables that increase cognitive effort. We focus mostly on the effects of two BEEs: incentivization and losses. Summarizing results from different meta-analyses, we find a small but robust positive effect size for BEEs, with comparable effect sizes to those found in studies of pharmacological cognitive enhancers.

Introduction

Meta-analyses reveal some robust positive results for the effect of certain attention-enhancing medications, particularly methylphenidate, independently of attention-deficit/hyperactivity disorder (ADHD) symptoms. In a meta-analysis incorporating 16 double-blind studies of healthy adults *without* ADHD, Marraccini et al. (2016) reported a positive effect of methylphenidate on speeded processing accuracy, with an effect size of 0.28. A somewhat smaller effect size of around 0.20 was reported in Roberts et al.'s (2020) meta-analysis of cognitive performance (see also Ilieva et al., 's 2015 meta-analysis of methylphenidate and amphetamine). Importantly, a similar effect size was reported in a meta-analysis of the effect of methylphenidate on adults *with* ADHD (e.g., d = 0.22 across cognitive domains in Pievsky and McGrath, 2018). In addition, several studies directly examining the selective effect of methylphenidate found equally improved sustained attention and short-term memory of people with and without ADHD, with no significant interaction between the effects of drug and diagnosis (Agay et al., 2010, 2014; Yechiam and Zeif, 2022). Those who benefit most from the effect of methylphenidate seem to be individuals with low baseline performance (Agay et al., 2014; Finke et al., 2010; Mehta et al., 2000; Zack and Poulos, 2009; see also Mehta and Riedel, 2006 for different results).[1] The current paper examines the possibility that behavioral economic variables might similarly have a small but robust effect on cognitive performance and judgment biases. We refer to relevant variables as behavioral economics enhancers (BEEs).

[1]A somewhat lower effect size of about 0.1 was reported for some other cognitive enhancers in healthy individuals, including an effect of modafinil in non-sleep-deprived individuals (Kredlow et al., 2019; Roberts et al., 2020) and an effect of selective serotonin reuptake inhibitors (SSRIs) on some cognitive domains in nondepressed adults (Prado et al., 2018).

Cognitive biases refer to systematic deviations from normative solutions (e.g., Caputo, 2013; Elkinton, 1941; Fischhoff, 1982; Mill, 1863; Tversky and Kahneman, 1974; Yang et al., 2021). The literature on *de*biasing was born out of attempts to examine the boundaries of biased responses as well as the practical need to alleviate biases (Fischhoff, 1982). Many approaches have been proposed to debiasing, and the present paper will only briefly mention those within the behavioral economics area and not cover the myriad of debiasing techniques within psychological and social sciences (for reviews of these, see, e.g., Fischhoff, 1982; Larrick, 2004; Lilienfeld et al., 2009).

Three historical developments have shaped the behavioral economics literature on debiasing and cognitive effort. The first was the notion of heuristics, namely the identification of fast and frugal information processing strategies that can lead to biases (Gigerenzer, 2004; Keren and Teigen, 2004; Tversky and Kahneman, 1974). An extreme point of view in this respect is that heuristics are the source of the most robust and prevalent biases (Kahneman, 2011). The second development is the notion that biases can be avoided if task information is provided in a clear fashion (Fischhoff, 1982), which is part of the 'boost' approach (Grune-Yanoff and Hertwig, 2016). A prominent example is Gigerenzer's (1996, 2004; Gigerenzer et al., 2011) influential work, which argued that people cannot deal with complex probabilistic information in an unbiased fashion unless probabilities are presented in frequencies or through other evolutionary adaptive means. The third development was the emergence of the 'nudge' approach (Thaler and Sunstein, 2008), a loosely defined set of debiasing techniques exploiting conditions actually leading to biases in order to divert decisions into advantageous paths. The nudge approach goes one step beyond the notion of heuristics in arguing that it is not only that biases are driven by automatic associative processes but also that *in practice* it is impossible to increase one's cognitive resources in order to avoid them. As noted by Thaler and Sunstein (2008), 'Most of us are busy and we can't spend all our time thinking and analyzing everything' (p. 23). Ergo, 'We're better off changing our immediate environment than believing that we can do it through the "power of the mind"' (Submarine Channel, 2018). Though second-generation nudge techniques incorporate the so-called educative nudges that act through people's relevant intellectual and knowledge capacities (Sunstein, 2016), these educative nudges focus on prescribing participants with information that supports appropriate judgment and decisions, and not increasing their sheer cognitive capacity.

Potentially though, these three developments are at odds with one another. At least in theory, heuristics can be overcome by deliberate effortful processing, while the nudge and boost approaches (implicitly or explicitly) discount the potential of inducing such deliberation. Indeed, behavioral economics scholars have generally been quite skeptical about the possibility that people can be somehow induced to increase their cognitive effort. For example, addressing the possibility that effort might reduce heuristics such as representativeness and anchoring and adjustment, Tversky and Kahneman (1983) indicated that 'we do not share Dennis Lindley's optimistic opinion that inside every incoherent person there is a coherent one trying to get out. . . and we suspect that incoherence is more than skin deep'. Camerer and Hogarth (1999) indicated that 'There is no replicated study in which a theory of rational choice was rejected at low stakes in favor of a well specified behavioral alternative, and accepted at high stakes'. Larrick (2004) further elaborated that 'For incentives to improve decision making, decision makers must possess effective strategies. . . the necessary "cognitive capital" to which they can apply additional effort. . . Incentives do improve performance in settings such as clerical and memorization tasks, where people possess the cognitive capital required to perform well but lack the intrinsic motivation. Few decision tasks, however, are analogous to simple clerical work or memorization'.

Some scholars have been careful to point out that in theory cognitive performance and judgments could be significantly improved by increased cognitive effort, but implementing this in practice is difficult (e.g., Arkes, 1991; Larrick, 2004). Importantly, both Arkes (1991) and Larrick (2004) theorized that certain types of decisions are more likely to be assisted by cognitive effort. Arkes' (1991) taxonomy of judgment and decision biases includes three classes of biases: The first class is psychophysically based biases that are driven by nonlinear translations of objective features, such as probabilities and time, into subjective attributes. An example is the (per capita) discounting of larger increases compared

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to smaller increases in one's outcomes known as 'diminishing sensitivity' (Bernoulli, 1782/1954; Kahneman and Tversky, 1979). The second class is association-based biases that are caused by fast and frugal problem-solving strategies, namely heuristics, and are triggered by the representations available in short-term memory (Arkes, 1991). This is exemplified by the Cognitive Reflection Test (Frederick, 2005), which was originally proposed as a judgment test capturing the usage of heuristic strategies versus more elaborate and reflective strategies (Frederick, 2005),[2] though some findings suggest that this test also measures numeric ability per se (Sirota et al., 2020; Welsh et al., 2013).

The third class of biases proposed by Arkes (1991) is strategy-based suboptimal behaviors (see also Larrick, 2004) reflecting the choice of strategies that are comprehensive but are nevertheless inappropriate for the problem at hand. Importantly, Arkes (1991) and Larrick (2004) maintained that it is biases of the second type—namely association- or heuristic-based biases—that are more likely to be assisted by cognitive effort. Arkes (1991) suggested that this may occur because cognitive effort leads to a more comprehensive search among possible problem solutions, which can yield more adequate responses, but cautioned that the search process driven by effort may itself be biased, and hence, 'neither the introduction of incentives nor entreaties to perform well will necessarily cause subjects to shift to a new judgment behavior' (Arkes, 1991, p. 494).

Other scholars have suggested that effort might in theory reduce the reliance on heuristics by triggering a less automatic and more deliberate processing mode. Indeed, a more recent taxonomy of biases was proposed by Stanovich et al. (2008) based on dual system theory (Denes-Raj and Epstein, 1994; Frederick, 2005; Kahneman, 2011). Though contentious (see, e.g., Chater, 2018; Keren and Schul, 2009), according to the theory, System 1 operates via heuristic and tacit reasoning, which can be performed rapidly, while System 2 uses more deliberative and slower processes with greater working memory requirements (Keren and Teigen, 2004). According to Stanovich et al. (2008), heuristic-related biases are subcategorized into two types. The first is cognitive miserliness, which is similar to the notion of association-based biases but is limited to cases where System 1 is at work while System 2 is deactivated. The second type is override failure, which involves cases where System 2 is activated but is overridden by System 1. Yet Stanovich and West as well have suggested that economic variables such as incentives often fall short of reducing System 1-related errors (e.g., Stanovich and West, 2004). Thus, both Arkes (1991) and Stanovich and West (2004) argued that cognitive effort can reduce judgment biases in theory but not in practice.

The notion that increased cognitive effort can in fact reduce judgment biases is supported by the findings of studies of attention-enhancing drugs. For example, Peled-Avron et al. (2021) found that methylphenidate improved performance in a simple perceptual judgment task. Franke et al. (2017) examined the effect of methylphenidate and modafinil on chess performance. Controlling for game duration (which was longer with modafinil and methylphenidate), both modafinil and methylphenidate enhanced chess performance as demonstrated by significantly higher scores. We examined the effect of two attention-enhancing drugs: methylphenidate and mixed amphetamine salts, on performance in the Cognitive Reflection Test (Yechiam and Zeif, 2022). The results indicated that the former drug led to a significant improvement in test scores, with an effect size of $d = 0.40$. The latter substance had a smaller and nonsignificant effect ($d = 0.07$). By contrast, several studies did not find an effect of methylphenidate on over/underweighting rate events and risk-taking (Agay et al., 2010, 2014; Yechiam and Zeif, 2022),[3] suggesting that its effect is limited to judgment biases resulting from fast and frugal processing.

In line with these findings and following theoretical predictions that at least in theory cognitive effort could reduce judgment errors driven by heuristics (e.g., Arkes, 1991; Larrick, 2004;

[2] For instance, consider the Cognitive Reflection test item: 'If it takes five machines five minutes to make five widgets, how long would it take 100 machines to make 100 widgets?' Addressing this item may evoke an immediate associative process (e.g., mentally completing the number list: 5, 5, 5, 100, 100, ?). However, the resulting judgment (an answer of 100) is wrong: The correct answer is five minutes.

[3] Daood et al. (2022) reported a negative effect of methylphenidate on hypothetical delay discounting for healthy adults, but a similar effect was not found in Shiels et al.'s (2009) study of children with ADHD.

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Stanovich et al., 2008), the current review focuses on the effect of BEEs on performance in general and specifically on judgment biases that are considered to be at least partially driven by heuristic processing (see also the more recent taxonomies of Datta and Mullainathan, 2014; Münscher et al., 2016). Our main focus will be on two BEEs: the effect of incentives and losses. For these variables, there is a proliferate literature and our review will thus take the form of a compilation and synthesis of relevant meta-analyses along with illustrative examples. This is followed by a more tentative discussion of other potential BEEs.

BEE 1. Incentivization

Incentivization is a key term in economics, and not only in behavioral economics, since rational people are assumed to respond to incentives (Mankiw, 2018).[4] However, in the context of cognitive enhancement the term is used differently than in standard economics in that participants do not know in advance what response or judgment will yield better incentives. In this respect, in the field of behavioral economics early findings supported the effect of incentives on performance (Edwards, 1956; Siegel, 1961; Tversky and Edwards, 1966), but this was followed by studies showing no or even negative effects of incentivization (e.g., Arkes et al., 1986; Fischhoff et al., 1977; Tversky and Kahneman, 1983), leading to a debate (see Hertwig and Ortmann, 2001; Gneezy et al., 2011).

On the other hand, in psychology several meta-analyses have established the robustness of the effect of incentives on cognitive performance. In a meta-analysis of 45 studies, Condly et al. (2003) reported an effect size of $d = 0.60$ for the effect of incentivization on performance in cognitive tasks and 0.88 in motor tasks. Also, there was no significant negative effect of incentivization on self-reported internal motivation. A larger meta-analysis of 146 studies was conducted by Garbers and Konradt (2014), who reported a somewhat smaller effect size of $d = 0.34$. Yet a third meta-analysis by Cerasoli et al. (2014) incorporated studies from school, work, and physical domains that used either incentivization or not. They also found a small positive effect size for incentivization in their moderator analysis ($\beta = 0.29$). Importantly, in all three meta-analyses the effect size did not differ between studies using quantity vs. quality indices,[5] suggesting that the effect of incentivization is not relevant only to repetitive or mundane tasks (as espoused, for instance, by Larrick, 2004). Nevertheless, an important question is whether this effect, observed in the psychology literature, also emerges for judgments, particularly those that are susceptible to heuristic-based biases.

In relevant judgment studies, there have been many mixed results. Some studies did not find a positive effect of incentivization (Awasthi and Pratt, 1990; Baillon et al., 2022; Enke et al., 2023; Tversky and Kahneman, 1983; Wright and Anderson, 1989), while others demonstrated it (Charness et al., 2010; Dale et al., 2007; Enke et al., 2023; Epley and Gilovich, 2005; Lefebvre et al., 2011; Simmons et al., 2010; Wright and Aboul-Ezz, 1988, in different biases). To stray from anecdotes and cherry-picking, we mainly focus on meta-analyses of the literature.

A recent meta-analysis of the effect of incentives on the Cognitive Reflection Test (Frederick, 2005) was conducted by Brañas-Garza et al. (2019). For their dataset, collected from 42,425 individuals examined in 110 studies, Brañas-Garza et al. (2019) reported no significant effect of incentives. However, this report suffers from several methodological challenges. First, Brañas-Garza et al. compared studies that used incentivization to those that did not. While their main analysis controlled for a variety of study-level moderators, this also reduced the sample size (by about 17%) due to missing values and introduced potential multicollinearity. Indeed, the null effect in Brañas-Garza et al.'s (2019) meta-analysis only emerged in their regression analysis including several study-level control variables.

[4] Indeed, some of the early economic criticism of Tverksy and Kahneman's work on heuristics was that they did not sufficiently incentivize participants (Harrison, 1994).

[5] An example of the former is the number of (above-criteria) floral arrangements put together in an hour, and an example of the latter would be the prominence of a single bouquet, for instance, as evaluated by an expert or by peers. Condly et al. (2003) noted that quantity indices are easier to define.

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Reanalyzing their meta-analysis for the simple effect of incentivization, we found the positive effect of incentivization to be significant though very small (d = 0.14; see Yechiam and Zeif, 2023a). Secondly, as noted in Yechiam and Zeif (2023a), Brañas-Garza et al.'s (2019) meta-analysis included two studies that did not strictly use monetary incentives as part of the incentivized study groups.[6] When these studies are removed, the simple effect of incentivization increases to 0.20 and a similar effect is recorded in regressions controlling for study-related characteristics.

In Yechiam and Zeif (2023a), we also conducted a more focused meta-analysis of eight studies that actually compared an incentivized Cognitive Reflection Test and a control condition with no incentives. Our results showed a small and significant effect of incentivization on test performance with an effect size of d = 0.21, which is comparable to the corrected effect size in Brañas-Garza et al. (2019). Differences in effect size between studies in this meta-analysis were mostly due to random noise rather than any moderating study-related effects.

In another meta-analysis (Yechiam and Zeif, 2023b), we examined the conjunction fallacy, one of the classical examples of judgment biases. Originally investigated by Tversky and Kahneman (1983), the conjunction fallacy is the tendency to estimate multiple contingencies occurring together as being more likely than one of the individual contingencies. Tversky and Kahneman (1983) presented this fallacy by proposing the problem now famously known as the 'Linda problem'. Linda is described as an outspoken, single, and very bright 31-year-old woman, who is involved with issues of discrimination and social justice. Participants are required to judge whether it is more likely that Linda is a bank teller, a feminist, or a bank teller who is active in the feminist movement. In this problem, the conjunction fallacy is evidenced by preferring the latter option over the two former ones. Tversky and Kahneman (1983) argued that this bias is mainly driven by the representativeness heuristic, a fast-and-frugal strategy for estimating probabilities based on similarity to representative examples (e.g., Linda seems more similar to a feminist bank teller than to any bank teller). Our meta-analysis of 11 conjunction fallacy studies (Yechiam and Zeif, 2023b) showed a small positive effect of incentivization on judgment performance in conjunction fallacy problems (d = 0.19 for all problems; d = 0.24 for the Linda problem). Again, disparities between different study results were mostly due to random noise. In addition, the effect size was stronger when calculating odds ratios as compared to absolute differences, suggesting a moderating effect of baseline performance (without incentives), similar to that observed for pharmacological cognitive enhancers (Agay et al., 2014).

Finally, a meta-analysis of the literature on the anchoring and adjustment heuristic was conducted by Li et al. (2021). This involved 56 product pricing studies that were incentivized or not and evaluated the effect of monetary-amount information presented as an anchor before participants made their pricing decisions. Specifically, the meta-analysis estimated the correlation between the (arbitrary) anchor and the elicited price. Li et al.'s (2021) data indicated that the correlation denoting the degree of anchoring and adjustment dropped from 0.31 with no incentives to 0.24 with probabilistic incentives (for a random item) and 0.16 with full incentives. A reanalysis shows there was a significant moderating effect of incentives in the direction of lower correlation ($B = 0.13$; $p = .02$).[7]

Thus, it seems there is a rather robust though small-sized effect of incentivization on judgment biases in meta-analyses consistent with the notion that incentives can reduce heuristic-driven biases, at least to some extent. Importantly, the smallness of the effect can explain the haphazard literature since with Cohen's d of 0.2, most small-scale studies would find no significant results (e.g., only 17% of studies with n = 100 will find the effect to be significant).

[6]For example, in one such study participants were incentivized for 'carefully filling in the questionnaire' (Lubian and Untertrifaller, 2014).

[7]This effect was smaller and not significant in the authors' models that sub-grouped incentivized studies into full and probable incentives and also included additional covariates. These covariates led to missing cases (7% of the studies were removed), and several of the additional predictors were correlated with the incentivization variable.

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BEE 2. Losses

Within behavioral economics, the effect of losses was addressed using two very different perspectives, that is, as a bias (e.g., loss aversion; Kahneman and Tversky, 1979) or as an attention-enhancing variable (e.g., Lejarraga and Hertwig, 2017; Yechiam and Hochman, 2013a). In some settings, when poor performance implies getting more losses and successful performance avoids or reduces losses, both of these aspects are expected to lead to a performance-boosting effect of losses. However, in other cases, for instance, when losses are provided irrespectively of one's performance, or when the loss is too small to elicit loss aversion, the bias approach predicts that losses should no longer improve performance, whereas the attentional model would suggest that the performance-enhancing effect of losses is robust.

In a recent meta-analysis, Ferraro and Tracy (2022) reported a positive effect of losses (compared to gains) on productivity in economic experiments, with Cohen's d of 0.33 for laboratory studies and 0.12 for field studies. This echoes earlier reviews showing a robust effect of negative outcomes on cognitive performance, which exceeds the effect of positive incentives (Baumeister et al., 2001; Rozin and Royzman, 2001; Yechiam and Hochman, 2013a). However, this literature cannot disentangle the bias and the attention models because it focuses on cases where successful performance reduces losses.

What about judgments? In their meta-analysis, Brañas-Garza et al. (2019) did not have a sufficient number of studies using losses. Indeed, the only study that we are aware of that examined the effect of losses on the Cognitive Reflection Test in an unpublished study by Carpenter and Munro (2023). Interestingly, these authors as well found that the effect of losses exceeded the effect of gains on cognitive reflection.

But is this performance advantage of losses a cognitive-boosting effect or merely a bias due to loss aversion? Several experiments have shown that losses have performance-enhancing effects even for small losses where no loss aversion is demonstrated. For example, Yechiam and Hochman (2013b) and Yechiam et al. (2015) found no loss aversion for losses of 1 token (worth less than a cent) in a repeated experiential decision task. However, the same small loss was found to increase maximization in different choice problems that involved simple quantitative judgments between varying amounts. In addition, losses were found to positively affect performance even in settings where elevated performance did not lead to getting fewer losses or even when it led to getting more losses (Yechiam et al., 2015, 2019; Yechiam and Hochman, 2013b). For example, Yechiam et al. (2015) examined a decisions-from-experience task with three choice options: an advantageous option and a disadvantageous option that produced either minor losses (in a loss condition) or minor gains (in a gain condition), along with a medium expected value option that did not produce any losses (see Figure 1). Under loss aversion, the loss condition should result in more choices from the medium expected value option since it eliminates the prospect of getting losses. However, the results showed a rather different pattern. As indicated in Figure 1, losses led to more selections from the advantageous option and fewer choices from the medium and disadvantageous options. Thus, losses increased the rate of advantageous selections even though advantageous selections actually produced more losses. This shows sufficient conditions for the attentional cognitive-enhancing effect of losses.[8] Similarly, in a perceptual judgment task, taxing the participants' payoffs (by either 10% or 30%) produced a positive effect on judgment performance even though more accurate judgments did not reduce the participants' taxes (Yechiam and Hochman, 2013b).

The cognitive enhancement effect of losses thus seems to be pertinent for small losses for which there is no loss aversion (Zeif and Yechiam, 2022). Importantly, the behavioral economics literature has often explained the effect of difficult goals on performance as evidence of loss aversion due to the implied loss frame incorporated by goals (e.g., Allen et al., 2017; Corgnet et al., 2018). However, the sheer attentional effect of losses accounts for this effect of goals on performance and also explains why

[8] Although this is not a judgment problem, one could consider this decision as involving a simple quantitative judgment. Under Yechiam and Hochman's (2013a,b) model, the positive attentional effect of losses should hold as long as there are considerable expected value differences between options.

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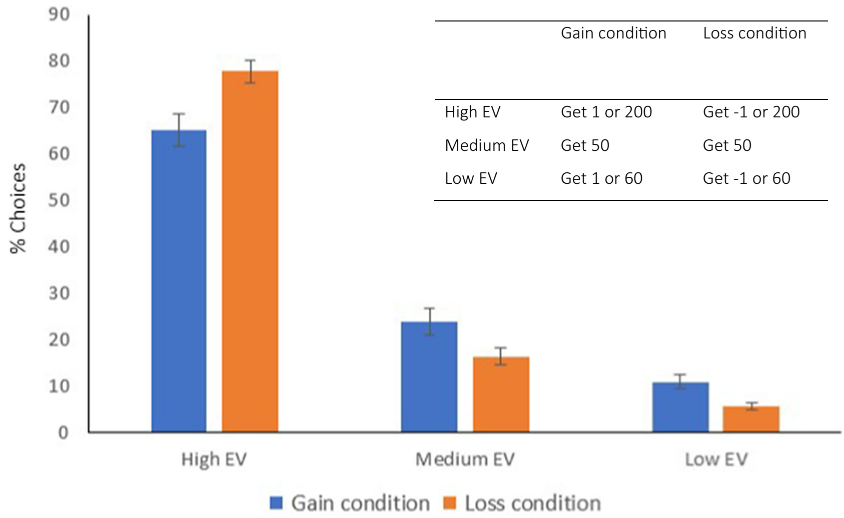

Figure 1. *The effect of losses on average choice rates in Yechiam et al. (2015). The task in this study involved 150 choices between three options, with either a high, medium, or low expected value (EV). The probability of the two outcomes in the high and low EV options was equal (50%). Participants were not provided with the payoff distribution, and each choice resulted in feedback drawn from the selected alternative's payoff distribution. Error terms denote standard errors.*

goals, like losses, improve performance when monetary amounts associated with goal failure are small (Corgnet et al., 2018; Gómez-Miñambres et al., 2012; Locke et al., 1968).

Mediators of BEEs

Most of the literature on process variables affected by BEEs focused on physiological indices and brain processes that are the hallmark of increased attention, yet very few studies actually examined the mediating effect of these process variables. For example, the presence of significant material consequences for successful performance was found to increase autonomic arousal and prefrontal activation in a multitude of studies (for some examples, see Gendolla and Richter, 2006; Gendolla and Wright, 2005; Richter and Gendolla, 2009; Sharpe, 2004; Wright, 1998; Wright and Kirby, 2001; Xue et al., 2009), yet none of these studies examined the mediating effect of brain activation patterns on performance. Similarly, the literature on losses shows that negative outcomes were found to have a larger effect on arousal measures and prefrontal activation (Gehring and Willoughby, 2002; Hochman and Yechiam, 2011; Löw et al., 2008; Satterthwaite et al., 2007; Tom et al., 2007), yet no study examined the mediation effects of these brain processes on cognitive performance and judgment biases.

A related question is whether these brain processes are similar to those produced by attention-enhancing medications such as methylphenidate. Research suggests some similarities. For example, both methylphenidate and incentives reduced activation in the default mode network (DMN) when administered to children with ADHD (Liddle et al., 2011). The DMN is the brain area activated when individuals invest their attention in off-task activities, namely mind wandering and daydreaming. Similarly, both incentivization and methylphenidate increased the activation of the anterior cingulate cortex in children with ADHD as evidenced by greater error-related negativity and error positivity (Groom et al., 2013).

There are other variables that can potentially mediate the effect of BEEs. One of them is the sheer increase in processing time directed at the task at hand (Ayal et al., 2015; Bettman et al., 1990), which interestingly is not usually found in studies of pharmacological cognitive enhancers

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(Marraccini et al., 2016; see also an exception in Franke et al., 2017). For example, in several studies it was shown that losses increased deliberation time (Porcelli and Delgado, 2009; Xue et al., 2009; Yechiam and Telpaz, 2013). In other studies, it was found that when participants are encouraged to deliberate, Cognitive Reflection Test performance improves (Patel et al., 2019; Sjastad and Baumeister, 2023; Szollosi et al., 2017) and judgment biases such as the conjunction fallacy (Scherer et al., 2017) and the contrast effect (Finucane et al., 2000) are reduced. Yet so far, no study has investigated the incentive-related mediating effect of deliberation time, and this remains an important challenge.

Moderators of BEEs

As noted above, Larrick (2004) and others suggested that cognitive effort only improves performance in judgment tasks that are relatively monotonous and where participants possess the relevant strategies to correctly perform the task. Unpacking this implies an effect of task type, with a positive effect predicted in decision tasks where biases are driven by fast and frugal heuristics, but also exclusively in tasks where participants' cognitive effort is not high to begin with, for instance, due to low motivation or interest and/or the monotonous nature of the task (see also McGraw, 1978).

With respect to task type, there are some studies showing that incentivization does not affect biases that are typically argued to be driven by automatic psychophysical transformations (though for most of these biases there are also theoretical explanations based on heuristics). For example, studies of delay discounting indicated that paying participants did not reduce the degree of discounting of future outcomes (Brañas-Garza et al., 2023; Johnson and Bickel, 2002; Lagorio and Madden, 2005; Locey et al., 2011; Matusiewicz et al., 2013). Also, incentivization did not reduce the overweighting of small probability events (Astebro et al., 2015; Barreda-Tarrazona et al., 2011) or underweighting of high probability events (Barreda-Tarrazona et al., 2011) in decisions from description. It also did not reduce the endowment effect (Yechiam et al., 2017), sellers' tendency to price objects higher than potential buyers do (Kahneman et al., 1990). Thus, possibly, the effect of incentivization might be restricted to poor judgments driven by association-based biases.

With respect to effort level, however, the above-reviewed findings of a small but robust positive effect for one-shot judgments seem to contradict Larrick's (2004) and McGraw's (1978) view that the effect of incentivization is limited to simple and highly monotonous tasks. Rubinstein (2013) similarly argued that 'Human beings generally have an excellent imagination and starting a question with "Imagine that..." achieves a degree of focus at least equal to that created by a small monetary incentive' (p. 541). Yet as noted above, even in judgment tasks where participants are asked to imagine certain situations (such as the Cognitive Reflection Test), incentives were found to have an effect. Nevertheless, an effect of baseline effort level may exist at the individual level.[9] As reviewed above, this has been scarcely examined, but some support is evident in the meta-analysis of base rate fallacy, which suggests a larger effect of incentives when baseline performance is poorer (Yechiam and Zeif, 2023b).

Another important moderator was proposed by Hogarth et al. (1991). They suggested that in tasks where most of the time participants receive a negative (net) reward for their actions, incentives—and losses—will have a negative effect. Their studies on the effect of incentives can be explained as a tendency to underweight the small probability that methodically applying effort will yield a positive outcome. To an extent, these studies pre-shadowed the underweighting of rare event phenomena in decisions from feedback (Barron and Erev, 2003), though the two literature studies were not subsequently integrated.

[9]This is also implied by the inverse U-shape association between initial autonomic arousal and performance, that is, the so-called Yerkes–Dodson law (Yerkes and Dodson, 1908), which was extended to the initial attention level (see Kahneman, 1973).

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The search for additional BEEs

Though the current paper focused on two relevant BEEs, others could be gleaned by additional research. The effect of incentives reviewed above suggests that increased effort might also emerge from the posited close relationships between the person making the decision and the people or objects who/that will be affected by the decision. Though this is consistent with the increased arousal elicited by the presence of close others (Vogel et al., 2017), there is limited supporting evidence. McShane and Gal (2016) found that presenting hypothetical statistical problems as advice to one's close family compared to giving advice to an (unknown) medical doctor reduced judgment biases associated with misinterpretation of p-value. They also found that presenting these problems as giving advice to a person lowered these biases compared to answering them hypothetically. In a similar vein, Braga et al. (2015) found that when the Linda problem addresses hypothetical individuals living in one's country rather than in a different country this diminishes the conjunction fallacy.

On the other hand, and somewhat paradoxically, abstract construal, namely framing the problem as relating to others rather than oneself, to the past or future rather than the present, and to a place that is physically far away rather than close by (Trope and Liberman, 2010), was found to reduce certain judgment biases. Specifically, abstract construal was found to reduce the rate of responses consistent with the availability heuristic (Braga et al., 2015) and to increase utilitarian choices in the trolley problem (Xiao et al., 2015); this was attributed to a reduction in intuitive (or System 1) emotional processing. Still, the debiasing effect of closeness of others in some settings, such as in the conjunction fallacy (Braga et al., 2015), suggests that abstract construal may not be a robust BEE. Further research is required to disentangle the cognitive-enhancing effect of close vs. far benefactories and of abstract and concrete phrasing.

General discussion

The main conclusion from this review is that the behavioral economics discipline has cognitive-enhancing 'tools' that are as efficient (in terms of effect size) as the common drugs used in ADHD, both having a small-sized effect on cognitive performance and judgment biases. For instance, the effect size of incentivization on performance in the Cognitive Reflection Test in our meta-analysis (Yechiam and Zeif, 2023a) was around $d = 0.2$. This roughly falls between the effects of Adderall and methylphenidate on the Cognitive Reflection Test recorded by Yechiam and Zeif (2022) and is similar to the effect size in Ilieva et al.'s (2015) and Roberts et al.'s (2020) meta-analyses of the effect of methylphenidate on cognitive performance in healthy adults.

Why are these small-sized effects important given the fact that policymakers need to prioritize limited economic resources and that incentives do require resources? First, the findings suggest that the positive effect of incentivization is achieved even with small financial outcomes and that the size of the outcome does not strongly moderate the effect (e.g., Yechiam & Zeif, 2023a,b). In addition, the presence of potential losses seems to considerably increase the effect size of incentives on cognitive performance, as evident in the meta-analysis of Carpenter and Munro (2023), and there might be other factors or conditions that could further increase it. Especially, the effect of incentives might be stronger for certain segments of the population. For methylphenidate, for instance, there is ample evidence that the cognitive-enhancing effect is stronger for individuals with low baseline performance (e.g., Agay et al., 2014; Mehta et al., 2000; Zack and Poulos, 2009). This has not been extensively examined for behavioral economic variables such as incentivization and losses. Finally, in some settings it might be important to invest communal resources in order to avoid severe judgment and decision errors or in order to have a competitive advantage.

The reviewed findings further suggest some parallels between BEEs and pharmacological cognitive enhancers. Both cognitive enhancers and BEEs were found to have a small-sized effect on performance in judgment tasks where typically individuals make fast but incorrect choices, but were not found to overcome biases that seem to be based more strongly on the transformation of perceptions to

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sensations, such as risk aversion or the underweighting of rare events in decisions from experience (methylphenidate: Agay et al., 2010, 2014; Yechiam and Zeif, 2022; incentives: Bowman and Turnbull, 2003; Xu et al., 2019). Additionally, both methylphenidate and financial incentives were found to increase autonomic arousal and to affect similar brain networks (as reviewed above; c.f., Liddle et al., 2011). Possibly, there could also be a similarity in the adverse effects of methylphenidate and BEEs. For instance, methylphenidate (Hinshaw et al., 1992), incentivization (Benistant et al., 2022), and losses (Grolleau et al., 2016) were all found to increase task-related cheating behavior, possibly because of greater task effort and attention. Nevertheless, more focused and systematic studies are necessary to clarify the proximity between attention-enhancing drugs and incentives.

To conclude, the notion of BEEs presents quite a different approach to debiasing from the very commonly applied nudge approach. Nudges were originally designed as guides or gentle directions toward the correct decision or judgment and away from poorer ones. BEEs do not guide individuals.[10] For example, incentivized performers merely know that if the task is performed well, this will result in better economic outcomes. Thus, the BEE variable is not the feedback but the reward or cost of making an appropriate or inappropriate decision. In accordance with this notion, in the reviewed meta-analyses of judgment studies even though participants did not know in advance that a particular judgment would yield greater incentives, merely knowing that there were incentives was found to improve performance.

Similarly, losses were found to improve performance even when the same losses were given for the correct and incorrect answer, and even paradoxically, when there were slightly more losses for the correct answer than the incorrect answer. Thus, even though losses and negative framing are heavily used in the nudge literature, the notion of BEEs suggests they have an independent positive effect on cognitive effort, which can facilitate task performance.

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[10] Thus, BEEs are, in theory, implementable even when the designers of the decision architecture do not themselves know the correct decision.

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