

Reasons for Comfort and Discomfort with Pharmacological Enhancement of Cognitive, Affective, and Social Domains

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Abstract The debate over the propriety of cognitive enhancement evokes both enthusiasm and worry. To gain further insight into the reasons that people may have for endorsing or eschewing pharmacological enhancement (PE), we used empirical tools to explore public attitudes towards PE of twelve cognitive, affective, and social (CAS) domains (e.g., attention, mood, creativity). Participants ($N=1,408$) from Canada and the United States were recruited using Mechanical Turk and were randomly assigned to read one (and only one) vignette that described an individual who uses a pill to enhance a single domain. After reading the vignette, participants were asked how comfortable they were with the individual using the enhancement. People were significantly more comfortable when they read about enhancement of certain CAS domains (e.g. creativity) than others (e.g. mood). We found a modest negative correlation between comfort level and the degree to which the PE was perceived as changing core features of the person. We also found a modest correlation between comfort level and the degree to which the PE was perceived as improving success in life. Finally, using a sequential mixed method technique, we found that participants who felt uncomfortable about PE use

overwhelmingly focused on a lack of need and, to a lesser degree, expressed concerns about safety; those who felt comfortable about PE use most frequently mentioned the safety of the pill and its ability to provide a positive outcome. The data provide novel insights into public enthusiasms and concerns over the use of PE.

Keywords Enhancement · Experimental neuroethics · Public attitudes · Cognitive · Social · Affective

Introduction

The drive for self-improvement is an enduring feature of the human condition, yet a spirited debate has emerged over the prospect of using pharmaceuticals to enhance brain function. The dominant discourse focuses on improving concentration and wakefulness [1–5], selected memory systems [6–9] and mood [10–13]; however improvement of other domains has garnered less attention. Of note, there has been little discussion in the literature considering the issue of whether people prefer enhancing one or another domain, and essentially no information about what their reasons might be for holding such preferences. The present set of experiments explicitly addresses these issues.

The topic of brain enhancement has been contentious; some commentators wax enthusiastically about the possibility [14] while others regard it as disturbing [15, 16]. There appears to be substantial ambivalence at play: it seems that irrespective of whether one is an evangelist for, or troubled by the prospect of

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enhancement, most people feel at least *some* discomfort about the issue [17]. This study is part of a larger research program whose aims are to explore the sources of comfort and discomfort regarding pharmacological enhancement (PE). We conceive of discomfort as those feelings of uneasiness that are likely underlying people's concerns towards a specific issue. As with many new technologies, people may be uneasy about PE for a variety of reasons [18–23]. Studies about public attitudes towards the use of pharmacological enhancements have reported safety [24–27], coercion [28, 29] and fairness [30–32] as prevalent concerns among the public. Others have suggested that a general distrust of pharmacological agents can also be involved [33]. However, in a recent study we found little difference in attitudes towards PE and transcranial electrical stimulation as a cognitive enhancer [19] suggesting that other reasons may contribute in people's concerns towards enhancement. We developed three hypotheses that might explain why people feel either comfort or discomfort with the use of pills for enhancement.

The first hypothesis is based upon the recognition that a variety of cognitive, affective, and social (CAS) domains might be enhanced using pharmaceuticals. If a particular feature of these differing domains was an important contributor in people's attitudes towards CAS enhancement, then one can imagine that people's discomfort with the prospect of enhancing would vary amongst domains as had been previously demonstrated by Riis and colleagues [34].

If people do indeed feel differently about enhancing various CAS domains, what underlying features might account for such sentiments? One possibility offered in the literature is that people perceive that enhancing certain CAS domains has more or less of an impact upon core aspects of the person than others [35–40]. Despite considerable debate on this topic, there is scant empirical data to confirm or disconfirm this claim [34]. Our second hypothesis is then that people are less comfortable with brain interventions that they perceive to substantially change core features of the person.

While moral concerns such as changes to the core features of a person may shape comfort with PE, prior experimental work found that the public is *simultaneously* sensitive to both perceived consequences and to relevant virtues in their normative evaluations of PE [19, 41, 42]. For this reason, our third hypothesis is that people are more comfortable with PE when they think

that enhancing a specific CAS domain substantially contributes to success in life.

In the experiments described below, we set out to systematically explore these questions using the empirical tools of experimental neuroethics [19]. In particular, we have used the contrastive vignette technique to test the hypotheses listed above, and a novel sequential mixed methods analysis (See Contrastive Quantitized content analysis subsection) to systematically explore public attitudes towards PE in the absence of a precedent hypothesis. Together, these data add substantial richness to our exploration of public attitudes towards PE.

Experimental Methods

Building on the emerging experimental neuroethics approach [19], we used the contrastive vignette technique [43] to explore public attitudes toward pharmacological enhancement. By enabling the experimenter to systematically manipulate key variables in the vignettes, this methodology allows one to apply quantitative rigor to issues of neuroethical salience. The key outcome measure is always the difference in group means between contrastive conditions rather than individual stated preferences. The present set of experiments uses a mixed-methods design; not only were standard quantitative measures utilized, but also a novel technique in which content analysis of free-response answers are subjected to quantization and assessed in a contrastive fashion.

The vignettes explored attitudes towards the propriety of pharmacological enhancement using a one-way between-subjects design in which the PE was described as an enhancement to one of twelve different CAS domains: ALERTNESS, ATTENTION, COOPERATION, CREATIVITY, EMPATHY, MOOD, NARRATIVE MEMORY, OPENNESS TO EXPERIENCE, PERSEVERANCE, SELF-CONTROL, SOCIABILITY or WORKING MEMORY. The vignettes were specifically crafted to be plausible, minimally contrastive, and responsive to the hypothesis under consideration. To reduce actor–observer asymmetries that can bias participants, we designed the vignettes in the second person [44]. The vignettes were analyzed using the Flesch-Kincaid Reading Ease and Grade Level readability tests, and in each instance we confirmed that the text of the vignettes would be comprehensible by 15 to 21-year-olds. The vignettes were subject to cognitive pre-testing to insure that participants understood the thrust of the narrative [45]. Participants from Canada and the United

States were recruited via Amazon's Mechanical Turk [46–50], and were compensated \$0.25 for completion of the survey. After they accepted the assignment, they were directed to the external survey experiment (FluidSurveys.com). To preclude participants from participating in multiple surveys, we utilize an embedded javascript (<https://uniqueturker.myleott.com>) that excludes participants who have previously taken a similar survey. We also check IP addresses to ensure that participants do not try to participate multiple times by using different profiles, and we found no duplicate IP addresses. Thus, we are confident that there was no multiple participation.

The participants provided informed consent and answered demographic questions about their age and biological sex. Participants were randomly assigned to one (and only one) version of a vignette describing an individual (John) who in the second question is described as a close friend and used a pill to enhance one of the twelve CAS domains (Text S1). It is plausible that attitudes towards PE are different for a friend than towards an unrelated person, but our analysis focuses upon the differences *between* contrastive conditions rather than the stated preference; thus any effects of using the friend in the vignette would be cancelled out. We selected the domains by reviewing the self-identity, personality, and bioethical literature, and developed the following five criteria. First, the chosen domains should reflect a range of social, affective, and cognitive abilities [34, 51–55]. We purposefully include domains that are regarded as fundamental to the core features of a person (e.g. SOCIABILITY or MEMORY) and those that are not (e.g. ATTENTION and ALERTNESS). Second, we chose domains that generally fit within one or more dimensions of the Big Five Model of personality (Agreeableness, Extraversion, Conscientiousness, Openness to experience, and Neuroticism) [51, 53, 54]. Third, we strove to include domains for which brain interventions already exist (e.g. MOOD) or that could plausibly be manipulated pharmacologically (e.g. EMPATHY) [56]. However our vignettes did not refer to specific agents and therefore respondents were presented a scenario that was hypothetical. Fourth, we selected domains that people want to improve, relying on evidence from both the academic literature and the popular press [11, 14, 57–61]. Fifth, we selected domains that could be described in a specific yet succinct manner, as we only provided our participants with a few words describing each of the domains in question. In particular, to ensure that all participants

interpreted the CAS domains in a similar way, we provided both a domain descriptor (e.g. sociable) and a specific domain definition (e.g. outgoing in social situations) in the body of the vignette (Table S1).

After reading their vignette, participants were asked three identical questions with answers provided on a 101-point sliding scale that ranged from –50 to +50. The primary outcome question asked participants to rate how comfortable they felt with the use of the pill, with anchors of *not at all comfortable* and *completely comfortable*. A free-response box followed after the first question, asking participants to provide, in their own words, their reasons for answering as they did, and this provided the data for the quantitized content analysis. The two follow up questions were presented on successive pages together with the vignette, which was included for reference purposes only. Question 2 asked participants to rate the degree to which the use of the PE changed the individual, with anchors at *the same person* and *a changed person*. Question 3 asked participants to rate how much the use of the PE contributed to the individual's success in life, with anchors at *a very small change* and *a very large change*. To confirm participants read the vignette carefully, we provided a comprehension check at the end, which asked which of four possible CAS domains the individual in the vignette had been trying to improve. After completing the comprehension check successfully, participants were given a code that they used to receive payment. The University of British Columbia's Behavioural Research Ethics Board approved the experimental design.

Statistical Analysis

Data were analyzed using the SPSS statistical package. Responses to slider questions were adjusted by adding 50 points to each data point to provide results ranging from 0 to 100. To insure that samples were sufficiently powered, we used a power calculator to determine the minimum number of responses required (<http://www.stat.ubc.ca/~rollin/stats/ssize/n2.html>) and set the power to 80 % to be sensitive to Cohen's $d=0.5$ (medium effect). In accord with evolving statistical standards, we emphasize effect size (ES) and confidence intervals (CI) [62], while also reporting significance testing (p-values).

Contrastive Quantitized Content Analysis

In order to obtain a richer account of public attitudes towards pharmacological enhancement, we use a novel mixed methods strategy [63]. We began with traditional content analysis of the free-responses and developed themes iteratively as the coding process progressed [64, 65]. Inter-coder reliability was determined by randomly selecting 10 % of the comments and assigning them to a second coder who was not involved with the initial coding process [66]. Inter-coder percent agreement was 96 %, and Cohen's Kappa coefficient (κ) 0.79. Each theme was quantitized [67, 68], allowing us to compare the frequency of themes across the contrastive conditions. It is the *contrastive* analysis of the quantitized data set that gives novelty to this sequential mixed methodology [63]. We employed descriptive statistics to characterize the composition and properties of the sample [67] and inferential statistics to test if any observed differences between contrastive conditions is meaningful.

Results

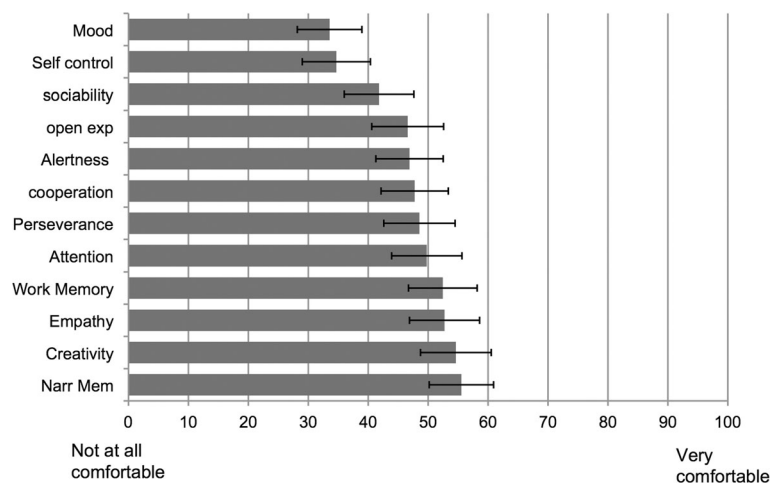
The data are based upon results collected from 1,486 participants who took the survey. From this, 28 respondents were eliminated from analysis because they were not located in the US or Canada (as determined by examining IP addresses), and 50 respondents were excluded because they either did not answer ($n=47$) or failed ($n=3$) the

comprehension check. This left us with 1,408 unique participants residing in Canada and the United States. The mean age was 29.9 and just over half (55.4 %) were male. Our sample is a convenience sample, and while the evidence to date suggests that Mechanical Turk provides reliable data [69], the subject pool is younger than and slightly more male than the general population, as well as being computer literate. Thus, our subject pool is not a representative sample of the general population [70].

Comfort Level

After randomly being assigned one of twelve vignettes, each participant answered a question which probed how comfortable they were with the individual in the vignette using a pill to enhance the particular domain highlighted in the vignette. A one-way, between subjects ANOVA revealed a significant main effect of domain ($F(11, 1,396)=6.076, p<0.001, \eta^2=.045$), with people most comfortable enhancing NARRATIVE MEMORY and CREATIVITY and least comfortable enhancing MOOD and SELF-CONTROL (Fig. 1). Post-hoc tests revealed that NARRATIVE MEMORY was statistically different from MOOD ($M_{diff}=21.98, 95\% CI [8.49, 35.49], p<0.001, d=0.726$), SELF-CONTROL ($M_{diff}=20.86, 95\%CI [7.17, 34.56], p<0.001, d=0.68$) and SOCIABILITY, ($M_{diff}=13.74, 95\%CI [.36, 27.12], p=0.03, d=0.43$). These data demonstrate that when it comes to public attitudes towards enhancing CAS domains, the particular domain in question matters.

Fig. 1 Effect of domain upon comfort level with enhancement. Error bars represent (95 %) confidence intervals



Changes to Core Features of the Person

Across the twelve CAS domains, we measured participants' perceptions of how large a change to the person as a whole might be wrought by a PE. A one-way ANOVA revealed a significant main effect of domain ($F(11, 1,396)=7.79, p<.001, p^2=.057$). Participants attributed larger changes to the person for pills that enhanced MOOD than any other domain (Fig. 2). The post-hoc tests revealed that ratings for MOOD differed significantly from NARRATIVE MEMORY ($M_{diff}=23.78, 95\% CI [11.99, 35.59], p<0.001, d=0.84$), PERSEVERANCE ($M_{diff}=20.33, 95\% CI [8.04, 32.62], p<0.001, d=0.72$), WORKING MEMORY ($M_{diff}=18.47, 95\% CI [6.94, 30.00], p<0.001, d=0.68$), ALERTNESS ($M_{diff}=15.638, 95\% CI [3.49, 27.78], p=0.002, d=0.55$), and CREATIVITY ($M_{diff}=15.14, 95\% CI [2.87, -27.42], p=0.004, d=0.53$).

In order to test the hypothesis that participants felt less comfortable with PE that produce larger changes in the person as a whole, we correlated participants' comfort with the use of PE with how much they perceived the PE instantiated changes to the person. We found an overall moderate negative correlation between comfort level and degree of changes to the person ($r=-.29, p<0.001$). The effect was most obvious at the extremes: participants were least comfortable with pills that enhanced MOOD while judging that MOOD PEs caused the largest change in the person as a whole, and participants were most comfortable with pills that enhanced NARRATIVE MEMORY while

perceiving that these PEs produced the smallest change in the person. It is worth noting that the results for some domains, such as ALERTNESS, did not fit this overall trend (Table S6).

Impact on Success in Life

Across the twelve CAS domains, we measured whether participants' judgments with PE might be affected by thoughts related to the consequences of using the pill. We asked participants how large of a role taking the pill would play in John's success in life. A one-way ANOVA revealed a significant main effect of domain ($F(11,1,396)=3.22, p<.001, p^2=.02$) (Fig. 3). Post-hoc tests revealed that CREATIVITY was statistically different from SELF-CONTROL ($M_{diff}=16.14, 95\% CI [5.12, 27.16], p<0.001, d=0.64$), MOOD ($M_{diff}=13.82, 95\% CI [2.96, 24.70], p=0.001, d=.53$), and ALERTNESS ($M_{diff}=11.06, 95\% CI [.22, 21.91], p=0.039, d=.44$). As can be seen from Fig. 3, improvement of SELF-CONTROL was perceived to have the least impact on success in life, whereas CREATIVITY was perceived to play the largest role in success in life.

In order to test the hypothesis that enhancements that are perceived as producing greater success in life increase comfort with PEs, we correlated participants' ratings of their comfort with John taking the pill with how much they thought PE contributed to success in life. We found an overall modest positive correlation between comfort level and success in life ($r=.25, p<0.01$). The effect was strongest in the

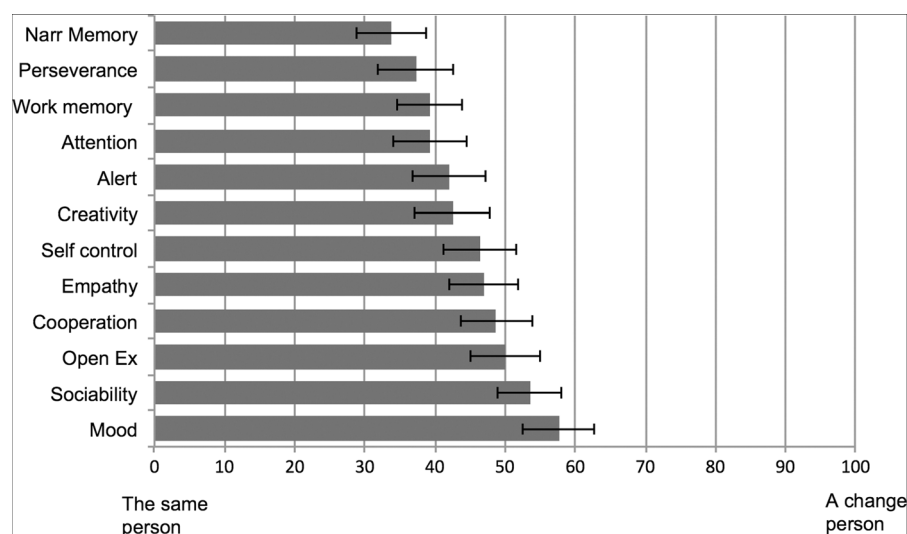
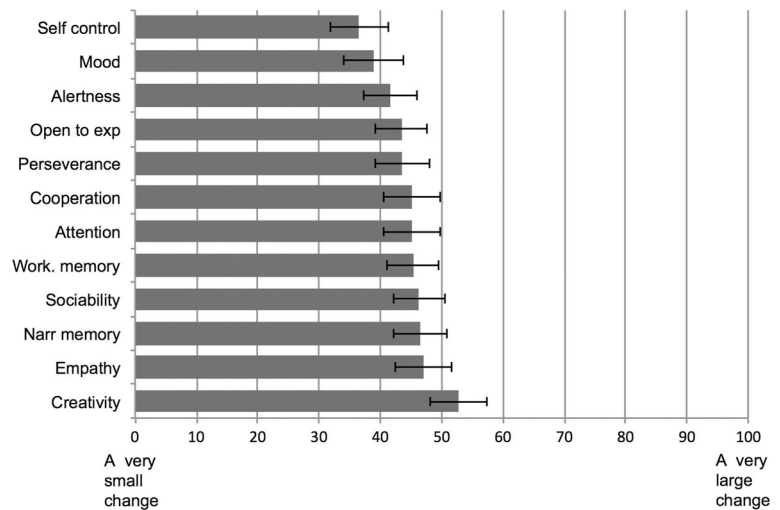


Fig. 2 Effect of domain upon perceived changes to person as a result of the enhancement. Error bars represent (95 %) confidence intervals

Fig. 3 Effect of domain upon perceived changes to success in life as a result of enhancement. Error bars represent (95 %) confidence intervals



domains ATTENTION, MOOD, ALERTNESS and WORKING MEMORY (Table S6). Thus, the data support the hypothesis that people are more comfortable with PE if the enhancement of the CAS domain in question is perceived as contributing to success in life (Fig. 4).

Reasons Offered for Attitudes Towards Enhancement

In an attempt to add philosophical thickness to this set of data, after rating how comfortable they were with the use of PE participants were asked to explain why they answered as they did in a free-response format. Responses were analyzed using qualitative content analysis (see methods) and the themes that emerged represented reasons that fell into four main categories: *Not Comfortable*, *Comfortable*, *Ambivalent*, and *Others*.

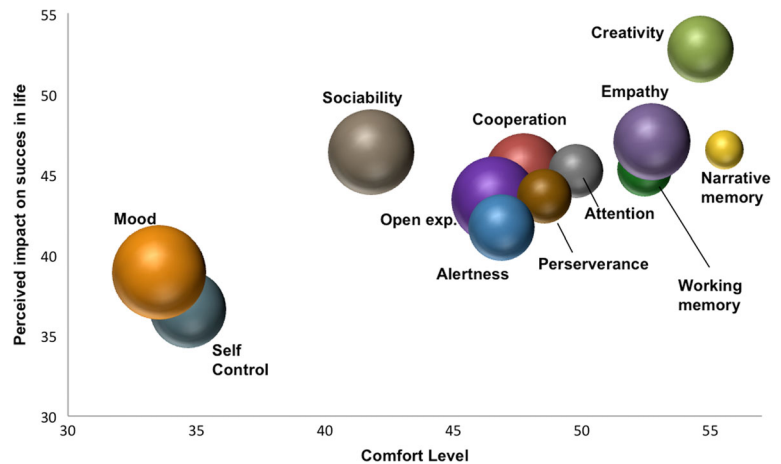
In the *Not Comfortable* category, five REASONS each accounted for >5 % of responses across all domains (Fig. 5): the notion that there is NO NEED to use PE ($n=608$, 43.2 %), concerns about SAFETY ($n=358$, 25.4 %), concerns about PILLS ($n=265$, 18.8 %), concerns about CHANGING THE BRAIN ($n=247$, 17.5 %), and concerns about CHANGING THE PERSON ($n=82$, 5.8 %). Notably, participants essentially dismissed three reasons that are often raised in the neuroethical literature: RELIGIOUS OBJECTIONS and SOCIAL PRESSURE were rarely mentioned (for each, $n=3$, 0.2 %), and the issue of DISTRIBUTIVE JUSTICE was explicitly mentioned only once among 1,408 comments (Table S2 and S3).

In the *Comfortable* category, five REASONS once again each accounted for >5 % of responses across all domains: that PE is SAFE ($n=351$, 24.9 %), PE provides a POSITIVE OUTCOME ($n=317$, 22.5 %), taking PE is an individual's CHOICE ($n=183$, 13 %), an overall ENDORSMENT OF PILLS ($n=172$, 12.2 %), and that the individual was INFORMED AND CONSENTED to the risks involved ($n=74$, 5.3 %).

A sizeable minority ($n=291$, 20.7 %) of comments expressed AMBIVALENCE about PE use. We characterized ambivalence as expressing both comfort and discomfort in the same comment, or (in a few cases) by the explicit mention of feelings of ambivalence.

In order to determine consistency between the quantized content analysis and the quantitative data, we calculated the NUMBER OF REASONS GIVEN for each participant by assigning to each *Comfortable* reason a +1 and to each *Not Comfortable* reason a -1; thus if an individual offered three reasons why they were uncomfortable, their NUMBER OF REASONS GIVEN would be -3. We then correlated the NUMBER OF REASONS GIVEN with each participant's rating of their comfort level in Q1 (Fig. 6). The resultant correlation coefficient of 0.80 suggests strong consistency between the quantitative and qualitative data. This analysis does not show how different reasons might have different influences upon people's attitudes; for some there might be only one main reason for their discomfort whereas for others with the same discomfort level several reasons might be in place. Nonetheless our results do support the idea that regardless of how different reasons might weigh in,

Fig. 4 Perceived changes to success in life as a result of the enhancement as a function of comfort level with the enhancement. The size of each bubble represents the degree to which it is perceived a person has changed by enhancing this domain



there is a relation between the number of reasons offered and people's levels of discomfort.¹

In order to determine whether the specific REASONS were evenly spread out across all twelve CAS domains or whether certain enthusiasms or concerns were particularly prominent when participants were presented with specific domains, we carried out a chi-square analysis with column proportion (using Bonferroni correction). For reasons expressing discomfort with use of PE, we found that NO NEED ($\chi^2=70.08$, $p<.001$) differed significantly between domains; using the z-test² we found that NO NEED arose significantly more often for MOOD ($n=76$, 65.5 %), SOCIABILITY ($n=66$, 55 %) and SELF-CONTROL ($n=63$, 57.3 %) compared to the other nine CAS domains (Fig. 7).

For REASONS expressing comfort with PE, we found that POSITIVE OUTCOME of the pill differed significantly between domains ($\chi^2=36.98$, $p<.001$). Again, using the z-test we found that POSITIVE OUTCOME was significantly more frequently mentioned for NARRATIVE MEMORY ($n=39$, 29.8 %), EMPATHY ($n=36$, 32.7 %), CREATIVITY ($n=36$, 31 %) and WORKING MEMORY ($n=32$, 25.2 %), than for all the other CAS domains (Fig. 8). We found that feelings of AMBIVALENCE were evenly distributed among all domains ($\chi^2=7.0$ $p=.80$).

¹ The limitations of this analysis is that we do not know how different reasons might have influenced the level of comfort or discomfort.

² Using the z-score test we can compare which column proportions differ significantly from each other at the 0.05 level (we used Bonferroni correction).

Discussion

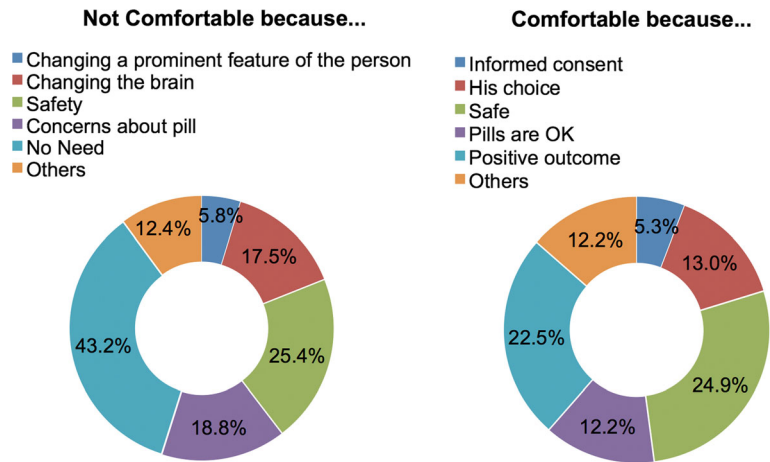
The present experiments explored how people feel about pharmacological interventions that improve twelve different CAS domains. Overall, the results indicate that people are more comfortable enhancing some CAS domains than others, that people are less comfortable enhancing domains that are viewed as substantially changing core features of the person, and that people are more comfortable enhancing domains that positively impact success in life. While one can imagine that people who are uncomfortable with an individual using enhancement might be less willing to use and view it as less acceptable (measures that have been used in other studies [19, 23]) than those who are more comfortable, this remains an open empirical question that we did not address in our study.

Comfort with Enhancement Depends on the Domain Being Improved

The results show that people are less comfortable using pills to enhance MOOD or SELF-CONTROL than they are with using a pill to enhance CREATIVITY or NARRATIVE MEMORY. Thus, the data demonstrate that domain matters. Yet what explains why people are more comfortable enhancing certain CAS domain than others?

Some argue that that status quo bias drives discomfort with enhancement [71]. According to this view, people should be less comfortable improving domains for which enhancement is a novelty than those for which the phenomenon has been in place for some time. The

Fig. 5 Most common REASONS under *Not Comfortable* and *Comfortable* categories n% of total of participants comments, $N=1,408$). REASONS that represented less than 5 % were collapsed under segment tagged “Others”



data in this study are at variance with this hypothesis: enhancing MOOD evoked the greatest amount of discomfort, yet the use of antidepressants as mood enhancers has been documented for over two decades [13].

A second possibility is that comfort with enhancement is driven by how much a given domain contributes to character [72]. Character, the aggregate of features and traits that form an individual, is intimately involved

in our judgment of individuals as moral agents, and is often taken to represent the set of virtues that defines an individual [73]. Some commentators have suggested that there is nothing morally wrong with improving our practice of the virtues with PE [74], but the issue can easily cut the opposite way: enhanced virtues might be construed as inauthentic. There is widespread agreement that SELF-CONTROL is a character strength [72] that

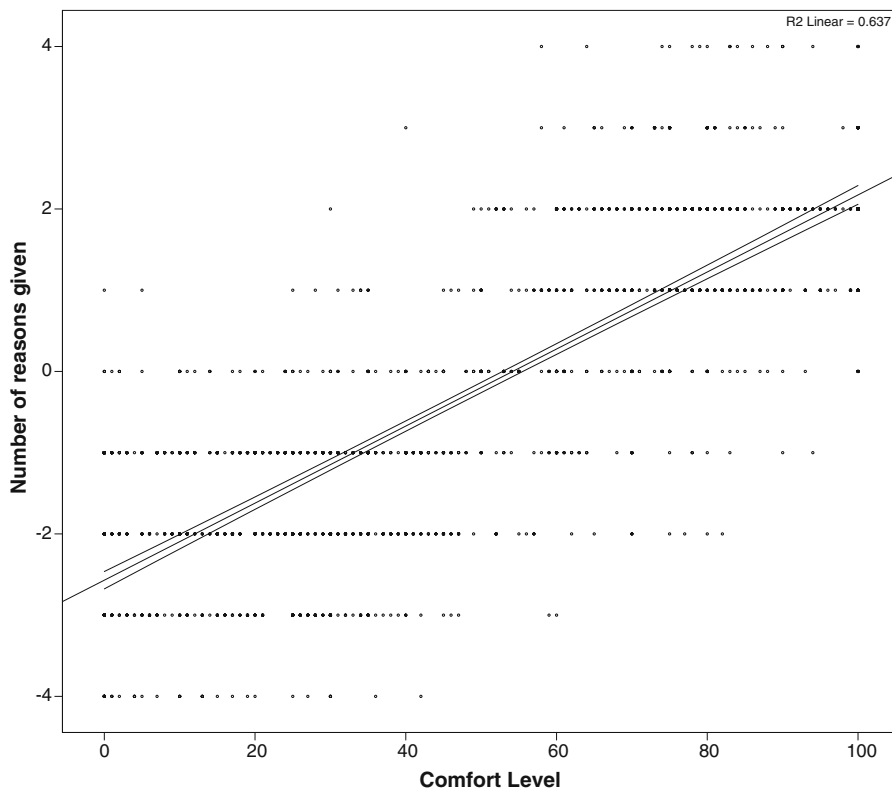
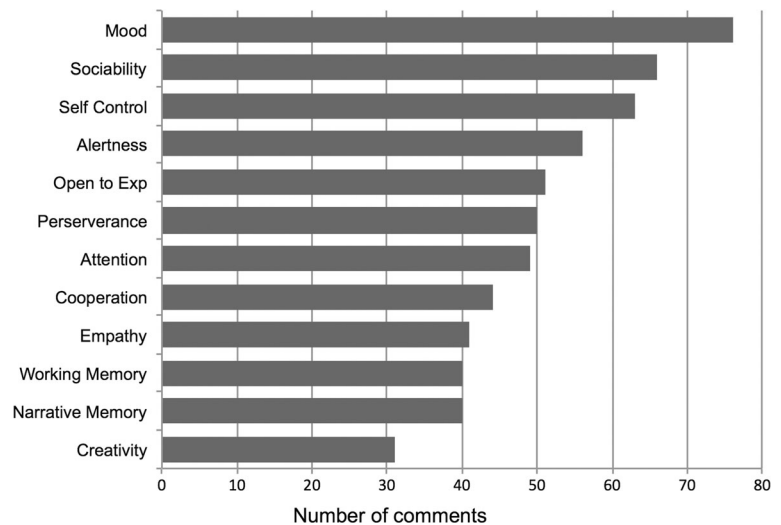


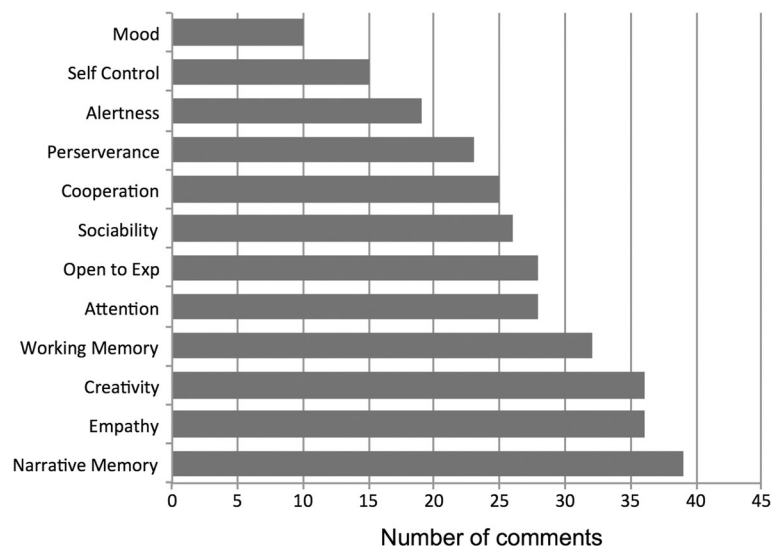
Fig. 6 Correlation between NUMBER OF REASONS GIVEN for each comment and the rating of comfort level

Fig. 7 Number of comments mentioning NO NEED per domain



brings about substantial benefits in terms of health, economic, and social, and academic achievement [75–78], yet participants were notably more uncomfortable enhancing SELF-CONTROL than other domains. At first glance, this might suggest that people are uncomfortable enhancing virtues, but participants were substantially more comfortable enhancing PERSEVERANCE, [79]. The most parsimonious conclusion is that the public do not view the impact of PE upon character as a key determinant of their comfort with enhancement, consistent with the neuroethical literature which de-emphasizes the notion of authenticity in the enhancement debate [37, 80–83].

Fig. 8 Number of comments mentioning POSITIVE OUTCOME per domain



Comfort with Enhancement Depends on How Much People Perceived it as Changing Core Features of the Person

It has been suggested that a substantial part of the discomfort regarding PE use is related to the degree to which the domain to be enhanced is fundamental to one's self-conception [34].

Our results are consistent with this conjecture, but only moderately so. We found only a moderate negative correlation between participants' comfort level with enhancing a certain domain and the degree to which the enhancement of that domain was thought to cause a

change in the person. It should be noted that our data does not directly address the question of how fundamental to one's self-conception a particular domain might be, but rather how large of a change to the person a PE might induce according to perceived changes in the domain in question. It has been suggested that domains considered to be fundamental to self-identity are generally regarded as stable [84–87], and the stability feature is “central to both everyday (lay) theories about the self and more formal (social science) theories about the self” [88].

Moreover, the content analysis of the free response data reinforces the notion that such effects are modest. Only 5.8 % ($n=82$) of our participants' reasons for discomfort indicated that their discomfort was associated with the fact that the pill changed a prominent feature of the person. Since these reasons were freely offered *before* participants saw the question about the changes to the person, one might be tempted to conclude that they better represent the *unprompted* attitudes of the public than answers to survey questions which inevitably bias participants' answers. Thus, we conclude that discomfort with PE is only modestly affected by the degree to which the domain to be enhanced is considered as fundamental to the core features of one's person.

Comfort with Enhancement Depends on How Much People Think it Impacts Success in Life

Public attitudes towards PE use consist of both tacit endorsement and guarded misgivings [19]. To a meaningful extent, people's moral views of PE are shaped by the consequences of using PE. To this end, some empirical studies report that people are concerned about safety and side effects [22, 89–92], while others are enthusiastic about the possible benefits [42, 93]. Such consequentialist sentiments were clearly evident in our data, as people were more comfortable with enhancement of domains that contributed more to success in life than the enhancement of those that contributed less to success in life.

Still, the data for two of the domains examined are inconsistent with generally held sentiments about their roles in providing success in life. There is ample evidence that people with a more positive mood are more successful, both financially and personally [94, 95], and that better self-control, as mentioned above, enables substantial benefits in terms of health, economic, social, and academic achievement [75–78]. Yet our participants

opined that the enhancement of these two domains played only a small role in one's success in life. It is certainly possible that assessments of the value of enhancing these domains were coloured by the high level of discomfort that participants reported when considering the issue. Irrespective of this surprising irregularity, the overall trend indicates that the public are indeed consequentialist in their feelings about PE use, and that success in life is one of the factors that drives comfort with enhancement.

Correspondence Between Public Sentiment and the Academic Debate

The comment analysis in this study provides an opportunity to gauge public sentiments about PE use in an unprompted fashion. In evaluating participants' *comfort* with PE use, we found that the free-response data corresponded with the arguments regularly provided in support of the use of PE in the academic literature [14]. In particular, participants were comfortable with the use of PE when they felt that it brought about a POSITIVE OUTCOME, and that it was the protagonists' CHOICE. The former reinforces the consequentialist perspective that abounds in modern western societies, whereas the latter reflects endorsement of the value of autonomy [96], in particular the notion that individuals should be free to choose what to do as long as their actions do not result in harm to others [97].

When we consider participants' *discomfort* with PE use, we find a different situation. In the debate about PE use, four cardinal concerns commonly arise: safety, fairness, pressure, and authenticity [19, 98, 99]. We note that among the five most frequent reasons for discomfort offered by participants, the only cardinal concern present was SAFETY. Moreover, among 1,408 participants, only a few participants raised issues about social pressure and coercion, and only one explicitly mentioned concerns about fairness or distributive justice. The latter could be the result of the fact that there was no mention of the cost of the pill in the vignettes, and it is possible if we had prompted participants with this information in the vignette, we would have gotten more responses about distributive justice. Further experimental work on the issue would be appropriate. A few participants also raised concerns about dependence and addiction, even though the vignette states that the pill “has been shown to have no side effects except for occasional

insomnia". One possibility is that our participants didn't read the vignette carefully, however given that only 3 out of 1,411 respondents failed the comprehension check, this seems unlikely. Another possibility is that people did not believe that there was only one side effect, and this seems more likely.

Of equal interest is the observation that naturalistic moral concerns and religious objections [100, 101] were rarely mentioned by participants.

Indeed, an issue that has fallen by the wayside in the debate over PE seemed to dominate participant attitudes: that enhancement was not needed. This concern is most prominent in commentary about the distinction between therapy and enhancement where it has been invoked as lack of medical necessity [102]. The notion that the public eschew PE because they view it as a frivolity is worthy of further consideration. These observations suggest that the concerns of the public with respect to the use of PE do not fully correspond to the concerns commonly discussed in the academic debate. Those interested in the issue of enhancement would do well to seriously consider the issues that people raise when thinking about PE.

Conclusions

The present study suggests that the particular domain that is enhanced plays an important role in people's comfort level with PE. The data in the present study is consistent with previous work from our research group [19] which suggests that the public offers tacit endorsement along with nagging doubts about the propriety of PE. Our results highlight the importance of recognizing that debate over PE use is not monolithic, and that each domain to be enhanced must be considered on its own merits. The data open the door to a rich field of empirical and normative study that will help determine which enhancements merit further scrutiny.

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Author Contributions

Conceived and designed the experiments: LYC NF PBR. Performed the experiments: LYC NF. Analyzed the data: LCY. Wrote the paper: LYC NF PBR.