

## On the Relation Between Oral Contraceptive Use, Boredom, and Flow

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**Abstract:** Across two samples, we investigated the relation between oral contraceptive (OC) use and self-reports of boredom and flow proneness in undergraduate females using OCs (Sample 1: OC group N = 343, Sample 2: OC group N = 162) and females not using any form of hormonal contraceptives (Sample 1: Non-OC group N = 1191, Sample 2: Non-OC group N = 852). We measured boredom proneness and the tendency to experience ‘flow’, defined as the experience of deep and effortless concentration; we also measured semester of data collection and symptoms of depression, anxiety and stress to use as control variables. Although there were some differences between samples, the key findings were that (1) boredom proneness and flow scores showed a modest negative correlation in both samples indicating they are associated but not simply opposite constructs; (2) OC users reported significantly less boredom proneness than non-users in Sample 2 and when the samples were combined, but this relation did not reach significance in Sample 1; (3) the association between OC use and boredom proneness remained even when semester of data collection and symptoms of depression, anxiety and stress were controlled; and that (4) there were no differences between OC and Non-OC groups for measures of flow proneness. Thus, OC use is related to reduced boredom proneness, although this relation is small.

**Keywords:** oral contraceptives, boredom, flow, deep effortless concentration.

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## 1. Introduction

There is a rapidly growing body of work examining the possibility that the use of oral contraceptives (OCs) influences cognition (see Gurvich et al., 2023; Warren et al., 2014 for reviews). This work is based on the notion that OCs influence the levels of endogenous and exogenous sex hormones in the body, which likely also includes various areas of the brain (Laird et al., 2019; Rehbein et al., 2021), which may lead to persistent changes in behavior at least for the duration of OC use. Thus far, the available evidence suggests that OC use is associated with variations in performance in some domains of cognition (e.g., visuospatial ability, mental arithmetic [Bradshaw et al., 2020; Pletzer et al., 2014] but not others (e.g., working memory [Islam et al., 2008; Kuhlmann & Wolf, 2005]). Although considerable progress has been made, the associations between OC use and some cognitive functions remain unresolved, either because the existing results are conflicting (e.g., mental rotation, difference detection, inattention) or because the required studies have yet to be conducted. This is particularly the case in the broad domain of human attention, in which, for example, the relation between OC use and mind wandering has been inconsistent across studies (Raymond et al., 2019; Smith et al., 2023), and the relations between OC use and other attention-related experiences, such as boredom and deep states of concentration (i.e., flow), have yet to be explored. Here, we take steps to fill this gap in the literature by examining the link between OC use and two aspects of attentional engagement, namely, boredom and ‘flow’ (i.e., states of deep and effortless concentration [Marty-Dugas & Smilek, 2019]).

### 1.1. Oral Contraceptives and Cognition

Hormonal contraceptives come in many forms (e.g., patch, injection), but the most common are oral contraceptives (OCs), which are used by more than 150 million women worldwide (United Nations, 2019). OCs are composed of exogenous (or artificial) estrogen and/or progesterone. They work by suppressing endogenous (or naturally occurring) levels of estrogen and/or progesterone (and replacing them with low-levels of artificial surrogates), which prevents pregnancy by primarily hindering ovulation, but also by increasing the mucus around the cervix (Frye, 2006; Rivera et al., 1999). However, endogenous estrogen and progesterone do not only act locally, nor are they solely synthesized by the gonads. The extant evidence suggests that peripheral estrogen and progesterone can pass through the blood-brain barrier (Banks, 2012) and that estrogen can even regulate the permeability of the blood-brain barrier (Sohrabji, 2006). Estrogen and progesterone also function as neurosteroids that are synthesized, and act on receptors, in the brain (Fester & Rune, 2021; Mellon & Griffin, 2002). The brain’s synthesis of these hormones suggests estrogen and progesterone levels could modulate neuronal excitability as well as the neural circuits related to many cognitive functions (see Galea et al., 2017; McEwen, 2002 for reviews). Since OCs chronically suppress estrogen and/or progesterone, studies have explored whether there are OC-related changes in neural activity by examining resting-state connectivity in OC users and non-users. These studies have revealed differences between OC users and non-users in the functional connectivity of several brain networks (e.g., salience, executive, reward, default mode networks [Petersen et al., 2014; Pletzer et al., 2016; Sharma et al., 2020]).

In light of the physiological effects of sex hormones on many aspects of brain function, it is perhaps not surprising that OC use has been associated with changes in performance in some

domains of cognition (see Gurvich et al., 2023 for a review). One aspect of cognition that appears to be different between OC users and non-users is the ability to perform mental arithmetic (Becker et al., 1982; Bradshaw et al., 2020; Pletzer et al., 2014). For example, Bradshaw and colleagues (2020) had hormonal contraceptive users (the majority of which were OC users) and non-users solve GRE math problems. They found that compared to non-users, those using hormonal contraceptives solved fewer problems correctly. Analyses of completion time data suggested that hormonal contraceptive users were performing worse than non-users because they spent less much time on each problem.

However, there are cognitive process that consistently appear to be unrelated to OC use (see Gurvich et al., 2023). For instance, most studies examining OC use and various working memory tasks—such as digit span (Gravelsins et al., 2021; Islam et al., 2008; Kuhlmann & Wolf, 2005), and n-back tasks (Gurvich et al., 2020; Herrera et al., 2020)—have not found significant relations between OC use and performance. The one exception is a study reported by Gravelsins et al. (2021), which revealed performance differences between OC users and non-users on the AX-CPT task, a task designed to tax both working memory and cognitive control mechanisms by varying stimulus-response contingencies based on contextual cues. However, the same study showed no influence of OC use on three other working memory tasks, including the n-back, digit span, and digit ordering. Thus, while OCs may influence performance on very specific tasks that involve working memory, the majority of the extant literature suggests that OC use is not related to differences in performance on most of the commonly used working memory tasks.

In still other cognitive domains, the relations between OC use and cognitive performance are less consistent and clear. One example concerns performance on visuo-spatial tasks such as mental rotation and difference detection (see Gurvich et al., 2023 for a review). While some studies in this domain show no relations between OC use and performance (e.g., Gogos, 2013; Gurvich et al., 2020; Patel et al., 2022; Wharton et al., 2008), others—typically those with larger samples—find that performance does differ between OC users and non-users (Beltz et al., 2015; Bradshaw et al., 2020; but also see Beltz et al., 2022). Another example of such mixed results occurs in the domain of inattention. One report, which assessed the relation between OC use and mind wandering using a subscale of the shortened Imaginal Process Inventory (Raymond et al., 2019) concluded that compared to the non-users, OC users experience *more* mind wandering. A contrasting conclusion was reported by Smith et al. (2023), who examined the relation between OC use and self-reported everyday inattention, as well as two types of mind wandering (spontaneous and deliberate). In one of their studies, Smith et al. (2023) found that compared to non-users, OC users reported significantly *less* spontaneous and deliberate mind wandering and *fewer* attention related errors, though the effects were quite small (all  $d$ 's  $\leq 0.20$ ). However, Smith et al. (2023) noted that these findings failed to replicate in another large sample, leading them to conclude that there does not seem to be a strong consistent link between OC use and inattention, especially as it pertains to mind wandering.

As is suggested by the foregoing, the relations between OC use and cognitive performance may depend on several aspects of the cognitive measures used to assess these relations. First, the *general cognitive domain* (e.g., working memory, visual perception, arithmetic) indexed by a measure seems to matter, with OCs evidently affecting measures that tap some domains and not others. Second, the specific cognitive *subdomain* being measured may

also be pertinent. For example, the broad domain of ‘attention’ can be divided into multiple subdomains, classically including but not limited to ‘mental concentration’, ‘vigilance’ or ‘sustained attention’, ‘selective attention’, ‘search’, ‘activation’, ‘mental set’, and ‘task switching’ (see Moray, 1969; Parasuraman & Davies, 1984; Pashler, 1998). It is certainly conceivable that OC use may influence some of these subdomains without meaningfully impacting others. Furthermore, even the nature of the specific measure used to index a particular cognitive subdomain may be important. For instance, OC use may influence self-reported levels of mind wandering assessed by the Imaginal Process Inventory report (Raymond et al., 2019), but not more targeted measures, such as the Mind-Wandering Spontaneous and Mind-Wandering Deliberate scales (Smith et al., 2023). In light of these possibilities, and given prior demonstrations of relations between OC use and some aspects of cognitive performance (Beltz et al., 2015; Bradshaw et al., 2020; Raymond et al., 2019), it seems prudent to continue exploring how OC use might influence various additional subdomains and measures of cognition. Along these lines, here we focus on two attention related subdomains, namely boredom and flow.

## 1.2. Boredom and Flow

Boredom is a negative experience that tends to arise when the current situation is lacking meaning, interest, and/or challenge, and has been described as wanting to engage with a satisfying activity but being unable to do so (Eastwood et al., 2012). This aversive experience is thought to provide motivation to change one’s behavior or situation. The available evidence suggests that there are individual differences in the propensity to experience boredom (Farmer & Sundberg, 1986; Hunter & Eastwood, 2018; Malkovsky et al., 2012; Struk et al., 2017; Tam et al., 2021), which has been most commonly measured using the Boredom Proneness Scale (BPS; Farmer & Sundberg, 1986) or the more recently refined Short Boredom Proneness Scale (SBPS; Struk et al., 2017). This individual trait appears to be related to other personality variables. For example, those higher in boredom proneness tend to also have reduced self-control and be lower in self-regulatory locomotion (the tendency to initiate and maintain goal-related actions) and higher in self-regulatory assessment (the tendency to evaluate and compare goal-related actions [Struk et al., 2016]). Relatedly, individuals higher in boredom proneness tend to have a lower sense of agency (Dadzie et al., 2024). Boredom proneness is also associated with poorer sustained attention in form of more attention lapses, attention related cognitive errors, and mind wandering (Carriere et al., 2008; Cheyne et al., 2006; Eastwood et al., 2012; Hunter & Eastwood, 2018; Malkovsky et al., 2012). There is also some evidence that those with a higher propensity for boredom are less likely to engage in and enjoy effortful cognitive activities (i.e., are low in need-for-cognition [Watt & Blanchard, 1994]). These correlates of boredom proneness may suggest a mechanism whereby the amount of control an individual perceives over their experience and the effort they are willing to put into engaging may shape their tendency to experience boredom (Wolff et al., 2025).

Boredom can be contrasted with the state of ‘flow’, in which an individual is completely immersed in a task, loses track of time, and finds the experience to be intrinsically rewarding (Csikszentmihalyi, 2000). This experience has also been described as being ‘in the zone’. While flow has been measured and conceptualized in variety of ways (Csikszentmihalyi, 2000; Jackson & Marsh, 1996; Marty-Dugas & Smilek, 2019), in recent work it has been characterized in terms of the experience of deep and effortless concentration (DEC), which is generally viewed as the

core aspect of flow—a perspective that appears to be gaining momentum (see Marty-Dugas & Smilek, 2019; Nakamura & Csikszentmihalyi, 2002 for a discussion of conceptual issues in flow). Individual differences in the tendency to experience DEC have been measured using the Deep Effortless Concentration Internal (DECI: focusing on thoughts) and External (DECE: focusing on external tasks) scales (Marty-Dugas & Smilek, 2019). The propensity to experience DEC, as indexed by the DECI/E, is negatively correlated with the tendency to experience attention-related failures (Marty-Dugas & Smilek, 2019) and positively related to both absorbing experiences (Marty-Dugas & Smilek, 2019) and mental well-being (Marty-Dugas & Smilek, 2020).

While the descriptions of boredom and flow suggest that these ought to be negatively correlated with each other (see Csikszentmihalyi, 2000; Weibel & Wissmath, 2024), they should not be considered as opposite experiences on the same continuum. We define boredom as being unable to engage despite wanting to (Eastwood et al., 2012), and we define flow as a deep effortless concentration (Marty-Dugas & Smilek, 2019). As such, flow may have multiple ‘opposite’ experiences other than boredom, such as deep, effortful concentration, or shallow, effortless concentration. Even when flow is defined more broadly, it is construed as being sandwiched between boredom on one end and anxiety on the other (see Weibel & Wissmath, 2024, Figure 11.1), suggesting that there is no single opposite pole of flow. Furthermore, boredom has negative affective components (e.g., apathy and anhedonia), and while flow may have positive affective *correlates*, they are not *components* of the experience as defined here in terms of deep, effortless concentration.

The evidence for a relation between OC use and boredom and flow comes from two lines of research. First, there is evidence that OC use, boredom, and flow all have been associated with activity in the default mode network (DMN; Danckert & Merrifield, 2018; Petersen et al., 2014; Pletzer et al., 2016; Sharma et al., 2020; Ulrich et al., 2014). Specifically, several studies have examined the relation between OC use and resting-state functional connectivity in the DMN (e.g., Petersen et al., 2014; Pletzer et al., 2016; Sharma et al., 2020). For example, Petersen and colleagues (2014) examined resting state connectivity in naturally-cycling females and females using an OC. Individuals in the naturally cycling group were further categorized by the phase of the menstrual cycle they were in at the time of scanning (luteal vs. follicular phase). The findings indicated that compared to non-users in the follicular phase, OC users (in both the active and inactive pill phase) showed decreased connectivity in some components of the anterior DMN (Petersen et al., 2014). Activity changes in the DMN have also been implicated in boredom and flow. For instance, Ulrich and colleagues (2014) found decreased activation in a part of the DMN (the medial prefrontal cortex; mPFC) during a condition in which people experienced flow compared to a condition in which they experienced boredom. Along similar lines, Danckert and Merrifield’s (2018) work on the neural correlates of boredom also implicated the DMN. This suggests that OCs could change the brain’s neural architecture in the DMN which may affect cognitive traits such as boredom and flow.

The second line of research suggesting a link between OC use, boredom, and flow involves investigations of the correlates of depression symptoms and negative mood. Several studies have demonstrated a link between OC use and depression (Cheslack-Postava et al., 2015; Duke et al., 2007; Hamstra et al., 2017; Keyes et al., 2013; Skovlund et al., 2016; Toffol et al.,

2012), although the direction of this association has varied across studies. Depression symptoms (or the lack thereof) may share some affective components with boredom and flow. For example, two depression symptoms are apathy and anhedonia, which are defined as a lack of interest or enthusiasm and an inability to feel pleasure (American Psychiatric Association, 2013). These experiences also arise in boredom when an individual fails to successfully engage with an activity—even though they may want to (Eastwood et al., 2012). In contrast, during flow, individuals are less likely to experience apathy and anhedonia because they are completely absorbed in a task (Nakamura & Csikszentmihalyi, 2002). Thus, another link between OC use, boredom, and flow is their relations with negative mood states, suggesting the possibility that OC use may be related to increased propensities to experience boredom, and a reduced likelihood of experiencing flow.

### 1.3. The Present Investigation

In the present studies, we investigated whether there was a link between OC use and boredom and flow proneness. We examined these relations using data from beginning of term surveys administered to undergraduates at the University of Waterloo. The surveys consisted of a large battery of psychological questionnaires and included items assessing OC use, as well as measures of the tendency to experience boredom (the Short Boredom Proneness Scale [Struk et al., 2017]), and of internal and external flow proneness (the Deep Effortless Concentration Internal and External scales [Marty-Dugas & Smilek, 2019]).

The surveys also contained measures of negative affect, including depression, anxiety, and stress (as part of the Depression Anxiety Stress Scale-21 [Antony et al., 1998]), which provided us with the opportunity to examine the relation between OC use and boredom and flow proneness while controlling for symptoms of negative affect. As noted above, many studies have shown links between OC use and mood (Cheslack-Postava et al., 2015; Duke et al., 2007; Hamstra et al., 2017; Keyes et al., 2013; Skovlund et al., 2016; Toffol et al., 2012), though the directionality of this relation has been contested. Some studies have indicated that OC use is related to *increased* positive mood (Hamstra et al., 2017; Keyes et al., 2013; Toffol et al., 2012), while other studies suggest a detrimental effect of OC use on affect (Skovlund et al., 2016), and still others showed no difference in negative affect across OC users and non-users (Cheslack-Postava et al., 2015; Duke et al., 2007). Most studies suggest anxiety and stress do not vary with OC use (Cheslack-Postava et al., 2015; Doornweerd et al., 2022; Kowalczyk et al., 2024; see also Jaafar et al., 2024). However, anxiety and stress have not been as well studied among OC users as depression. Nevertheless, we opted to account for the possible confounding effects of depression, anxiety, and stress by controlling for all these symptoms in our analyses.

Lastly, since our measures of interest were included in multiple semesters of data collection, we were able to aggregate the data across these semesters to achieve reasonably large samples sizes as well as test for replicability. Accordingly, we divided the data into two large samples. Sample 1 included data from Fall 2021 and Winter 2022. We used analyses of Sample 1 as the foundation for a pre-registered replication, which we refer to as Sample 2, and which included data from Fall 2022 and Winter 2023. To address the possible confound of time, we statistically controlled for the semester of data collection when assessing the relations between OC use, boredom, and flow.

Throughout this manuscript, we report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. These studies received ethics clearance through a University of Waterloo research ethics board (ORE # 45614). All participants provided informed consent prior to participation.

## 2. Sample 1

### 2.1. Method

#### 2.1.1. Participants

Participants consisted of undergraduate students enrolled in at least one psychology course at the University of Waterloo who indicated their sex as female. Participants received partial course credit in exchange for completing the Pre-screen and Mass Testing surveys (see below). The Pre-screen and Mass Testing surveys are shared by many researchers in the Department of Psychology at the University of Waterloo. As such, the only eligibility required to complete each semester's Pre-screen and Mass Testing surveys is enrolment in at least one undergraduate psychology that semester. As such, we aimed to collect data from as many participants as possible and then applied our a priori determined exclusion criteria for the present study following data collection. Participants were excluded from each semester based on the criteria outlined in the Data Cleaning section below. The Fall 2021 cohort included 1315 females, of which 450 were excluded. This left 865 participants, with 190 using OCs and 675 non-OC users who were not using any hormonal contraceptives. The Winter 2022 cohort was 1402 females and 733 were excluded, leaving 669 participants, with 153 OC users and 516 non-OC users. We collapsed across these two semesters to create Sample 1, which included a total of 1534 participants, with 343 participants using OCs and 1191 non-OC users. The mean age of OC users was 20.53 (SD = 2.29, range = 18–44). The mean age of non-OC users was 20.48 (SD = 3.24, range = 18–45).

#### 2.1.2. Pre-screen and Mass Testing Surveys

We collected data for this Sample at the University of Waterloo as a part of the Pre-screen survey and the Mass Testing survey. These surveys were administered to undergraduates enrolled in psychology courses and included a series of questions administered at the beginning of each semester in close succession. The Pre-screen survey included items asking about sex, gender, age, and hormonal birth control use. The hormonal birth control item was, "Are you currently using one of the following methods of birth control?". Participants responded by selecting from a list that included: oral contraception (i.e., birth control or "the pill"), birth control patch, vaginal ring, birth control injection, copper IUD, hormonal IUD, hormonal implant, none of the above, and prefer not to answer.<sup>1</sup> Other items asked participants whether they were currently being treated for depression and anxiety. The Mass Testing survey included a large battery of questionnaires. Relevant to the present study are 1) the Boredom Proneness Scale – Short Form (Struk et al., 2017), 2) the Deep Effortless Concentration – Internal, and the Deep Effortless Concentration – External scales (Marty-Dugas & Smilek, 2019), and 3) the Depression Anxiety and Stress Scale-21 (Antony et al., 1998).

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<sup>1</sup> Items assessing hormonal contraceptive use were included in the Pre-screen Survey at our request following ethics approval. To ensure confidentiality and data privacy, data were anonymized prior to data cleaning and analysis.

### 2.1.3. Data Cleaning

We utilized a similar data cleaning procedure as in our prior work (Smith et al., 2023; Smith & Smilek, 2024). Exclusion criteria were determined a priori unless otherwise stated.

In Fall 2021, we excluded participants for a) use of a hormonal contraceptive other than OCs (N = 12), b) use of an IUD (Copper N = 11, Hormonal N = 60), or c) failing to disclose whether or not they used a hormonal contraceptive (N = 94). Because the exogenous hormones in OCs could interact with psychotropic medications (see Damoiseaux et al., 2014), we also excluded participants who reported that they were currently being treated for depression (N = 145; OC N = 54, non-OC N = 91), or currently being treated for anxiety (N = 60; OC N = 24, non-OC N = 36). We also removed participants who did not respond to these items inquiring about mental health treatment (depression: N = 12; anxiety: N = 4). We also conducted data quality checks and eliminated poor quality data based on participants' patterns of responses. Specifically, participants were excluded due to speeded responses (we reasoned that participants needed at least 1-second per item to read and respond to the item in good faith; if they were faster than this, we removed them because this may indicate they were responding randomly; N = 34). Participants were also removed if they responded to fewer than half of the items on a scale (N = 2; responses on items for a given scale were averaged to arrive at the scale scores). Finally, to ensure our sample consisted of pre-menopausal females, the data were analyzed both before and after removal of participants based on an age criterion (age < 45). The removal of participants based on age did not impact the outcomes in a meaningful way. Below are reported the analyses of data after the removal of participants based on the age criterion. This included the removal of participants for either not reporting their birth year (N = 6) or being older than 45 (N = 7).

In Winter 2022, we applied the same exclusion criteria as in Fall 2021 with one additional criterion: we first excluded participants who were already included in the Fall 2021 cohort to ensure participants were not double counted (N = 306). Sixteen participants were excluded for using a hormonal contraceptive other than OCs and 64 participants were excluded because they used an IUD (Copper N = 13, Hormonal N = 51). We also removed 90 participants because they did not respond to the item on hormonal contraceptive use. One hundred and thirty-six (OC N = 54, non-OC N = 82) were excluded because they were currently being treated for depression and 59 (OC N = 23, non-OC N = 36) were excluded because they were currently being treated for anxiety. Twenty-one participants were also removed because they did not disclose whether or not they were currently being treated for depression or anxiety. We again excluded participants with poor data quality using the same three criterion as we applied in Fall 2021. In this process, 30 participants were excluded for speeding through a survey (using the same 1-second per item criterion as in Fall 2021) and 4 participants were also excluded because completed fewer than 50% of the items on the DASS. Like Fall 2021, we analyzed the data with and without exclusions based on age. This did not change the results in a meaningful way. The below analyses exclude participants who did not report their birth year (N = 6) or had an age greater than 45 (N = 1).

### 2.1.4. Materials

*The Short Boredom Proneness Scale (SBPS).* The Boredom Proneness Scale – Short Form is an 8-item measure used to assess the tendency to experience boredom (Struk et al., 2017). Participants respond to statements such as “I find it hard to entertain myself” and “In most

situations, it is hard for me to find something to do or see to keep me interested” and rate them on how typical the statements are of themselves on a 7-point scale that included anchors from 1 – *strongly disagree* to 7 – *strongly agree*. Higher scores indicate a greater tendency to experience boredom. Studies conducted during the development of the SBPS show that it is a valid and reliable measure of boredom and that it consists of a single factor (shown through confirmatory factor analysis [Struk et al., 2017]).

*Deep, Effortless Concentration Internal (DECI) Scale and Deep, Effortless Concentration External (DECE) Scale.* The DECI and DECE are trait-level measures of flow during internal tasks (such as thinking or remembering) and external tasks (such as sports or hobbies [Marty-Dugas & Smilek, 2019]). Each scale consists of eight items. Participants rate the frequency with which they experience internal and external flow. They respond to statements such as “When thinking/performing an external task, I get completely engaged without having to work at it”. Items are rated on a 7-point scale which included anchors from 1 – *never* to 7 – *always*. Higher scores indicate a greater frequency of flow experiences during internal or external tasks. The DECI and DECE are valid and reliable measures of internal and external flow experience (Marty-Dugas & Smilek, 2019).

*Depression Anxiety Stress Scale-21 (DASS-21).* The DASS is a 21-item screening measure assessing symptoms of depression, anxiety, and stress over the previous week (Antony et al., 1998). Participants rate items such as “I felt that I had nothing to look forward to” (depression), “I was worried about situations in which I might panic and make a fool of myself” (anxiety), and “I found it hard to wind down” (stress) on a scale from 0 – *did not apply to me at all* to 3 – *applied to me very much or most of the time*. The scale contains seven items related to each of depression, anxiety, and stress and is scored on these three subscales (DASS-Dep, DASS-Anx, DASS-Stress). Higher scores on the scale items indicate higher levels of these experiences. The DASS is a valid and reliable measure of symptoms of depression, anxiety, and stress (Antony et al., 1998).

## 2.2. Results and Discussion

We used R (R Core Team, 2017) and tidyverse to perform all data cleaning and analyses. We used the psych, stats, and basic R packages to perform the Null Hypothesis Significance Tests and the Bayes Factor package to calculate Bayes Factors (BFs). The Bayes Factor package calculates the BFs as the ratio of the alternative to null hypothesis, such that smaller BFs indicate evidence for the null hypothesis, while larger BFs are evidence for the alternative hypothesis. We interpret Bayes Factors based on Andraszewicz et al. (2015). Anonymized data and analysis scripts are available at <https://osf.io/f6xqa/overview>. We first conducted a series of planned comparisons between the OC and non-OC groups to determine if there were differences between OC users and non-users on each of our measures.<sup>2</sup> We then conducted a series of hierarchical regressions predicting the measures with OC use while statistically controlled for depression symptoms and the semester the data was collected.

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<sup>2</sup> We also compared depression, anxiety, and stress symptoms across OC and non-OC groups. However, since this was not a research question of interest in the current paper, these analyses are included in the Supplementary Materials.

## 2.2.1. Descriptive Statistics

Descriptive statistics for each measure as a function of semester (Fall 2021 vs. Winter 2022) and group (OC vs. Non-OC) are presented in Table 1. All scales showed high reliabilities, with Cronbach alphas of .81 or greater (Table 2). Pearson correlations between the measures within each group are also provided in Table 2. Figure 1 includes Boxplots depicting each of the measures as a function of OC use condition (averaged across semesters).

Table 1. Descriptive statistics of measures by semester and group for Sample 1

Semester	Group	Measure	N	Mean	SD	Skew	Kurtosis
Fall 2021	Non-OC group	SBPS	675	3.41	1.16	0.25	-0.47
		DECE	675	4.17	1.32	0.05	-0.50
		DECI	675	4.07	1.23	0.09	-0.03
		DASS-Dep	675	0.93	0.74	0.69	-0.40
		DASS-Anx	675	0.84	0.68	0.85	0.04
		DASS-Stress	675	1.08	0.65	0.37	-0.46
	OC group	SBPS	190	3.19	1.10	0.05	-0.81
		DECE	190	4.16	1.26	-0.07	-0.56
		DECI	190	4.13	1.22	0.10	-0.21
		DASS-Dep	190	0.81	0.73	0.95	0.20
		DASS-Anx	190	0.79	0.69	0.79	-0.34
		DASS-Stress	190	1.05	0.65	0.39	-0.43
Winter 2022	Non-OC group	SBPS	516	3.46	1.12	0.09	-0.68
		DECE	516	4.28	1.28	0.02	-0.27
		DECI	516	4.17	1.16	0.15	-0.19
		DASS-Dep	516	0.92	0.76	0.80	-0.08
		DASS-Anx	516	0.77	0.67	0.89	0.15
		DASS-Stress	516	0.97	0.69	0.63	-0.06
	OC group	SBPS	153	3.45	1.10	0.34	-0.66
		DECE	153	4.37	1.27	0.12	-0.58
		DECI	153	4.08	1.18	0.11	0.18
		DASS-Dep	153	0.81	0.72	1.19	0.81
		DASS-Anx	153	0.79	0.64	0.94	0.43
		DASS-Stress	153	0.99	0.64	0.76	0.24

Note. SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = DASS Depression Subscale, DASS-Anx = DASS Anxiety Subscale, DASS-Stress = DASS Stress Subscale.

Table 2. Cronbach alphas (left panel) and Pearson correlations (right panel) of the OC group (above the diagonal; N = 343) and non-OC group (below the diagonal; N = 1191)

Measure	OC Cronbach $\alpha$	Non-OC Cronbach $\alpha$	1	2	3	4	5	6
1. SBPS	.88	.88	--	-.37 **	-.30 **	.64 **	.46 **	.47 **
2. DECE	.97	.96	-.35 **	--	.49 **	-.28 **	-.21 **	-.27 **
3. DECI	.96	.95	-.31 **	.48 **	--	-.25 **	-.14 *	-.20 **
4. DASS-Depression	.91	.90	.54 **	-.18 **	-.15 **	--	.73 **	.73 **
5. DASS-Anxiety	.83	.81	.38 **	-.14 **	-.14 **	.67 **	--	.79 **
6. DASS-Stress	.84	.84	.40 **	-.16 **	-.15 **	.72 **	.76 **	--

Note. SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = DASS Depression Subscale, DASS-Anx = DASS Anxiety Subscale, DASS-Stress = DASS Stress Subscale. \*  $p < .05$ , \*\*  $p < .001$

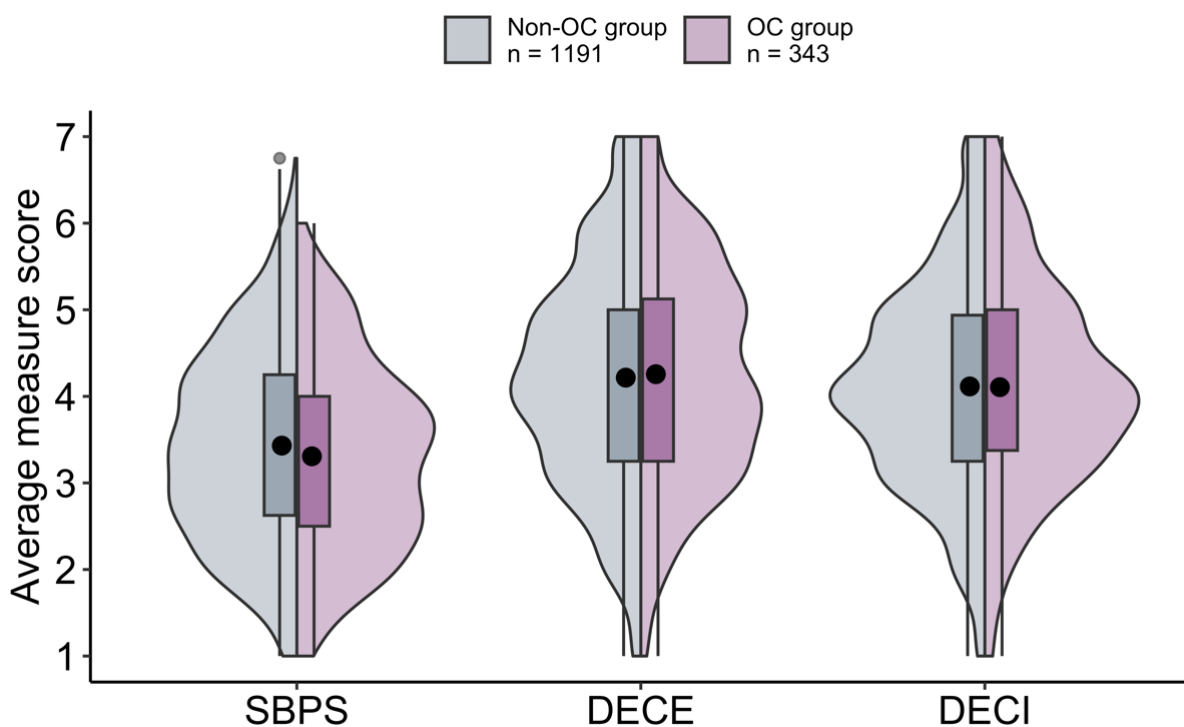
### 2.2.2. Correlations

In both groups, we found that boredom proneness was moderately negatively correlated with flow proneness (the DECI and DECE), which is consistent with the supposition that boredom and flow are negatively related but do not occupy exact opposite poles of a single continuum. Boredom proneness was also positively correlated with symptoms of depression, anxiety, and stress. In contrast, flow proneness was negatively related to symptoms of depression, anxiety, and stress.

### 2.2.3. Planned Comparisons

We collapsed across semester to conduct a series of independent samples t-tests comparing OC users and non-users on measures of boredom proneness and flow (Figure 1). To control for multiple comparisons, we utilized a Bonferroni correction, setting alpha at .017 (.05 / 3). We also calculated Bayes Factors to determine the evidence we had for the alternative or null hypotheses. For the measure of boredom proneness (i.e., the SBPS) there was no significant difference between OC users and non-users,  $t(569.8) = 1.81, p = .071, d = .11$ , and the Bayes Factor ( $BF_{10} = 0.32$ ), indicated there was moderate evidence for the null hypothesis. There were also no significant differences between OC users and non-users on measures of external flow (i.e., the DECE),  $t(567.1) = 0.51, p = .610, d = .03$ , and internal flow (i.e., the DECI),  $t(556.4) = 0.12, p = .906, d = .00$ . The Bayes Factors for external ( $BF_{10} = 0.08$ ) and internal ( $BF_{10} = 0.07$ ) flow revealed strong evidence for the null hypothesis in both cases.

Figure 1. Split violin plots with box and whisker plots (boxplots) for each of the measures (SBPS, DECE, and DECI) as a function of OC use in Sample 1



#### 2.2.4. Regressions

To determine whether oral contraceptive use was associated with boredom and flow proneness over and above symptoms of depression, anxiety, stress, and the semester of data collection, we conducted a series of hierarchical regressions. We entered semester and each of the DASS subscales (depression, anxiety, and stress)<sup>3</sup> as predictors in the first step and then added oral contraceptive use in the second step.

As can be seen in Table 3, when semester and depression, anxiety, and stress symptoms were entered in Step 1 they accounted for a significant amount of overall variance in boredom proneness ( $R^2 = .321$ , model  $p < .001$ ), internal flow ( $R^2 = .032$ , model  $p < .001$ ), and external flow ( $R^2 = .045$ , model  $p < .001$ ) measures. More specifically, in Step 1 both semester and depression symptoms accounted for a significant amount of unique variance when predicting the SBPS; in contrast, only depression symptoms (and not semester nor symptoms of anxiety and stress) accounted for significant and unique variance in the DECE and DECI. The inclusion of OC use in Step 2 did not explain additional variance in any outcome variable (see  $\Delta R^2$  in Table 3). In Step 2, semester and depression symptoms continued to predict significant unique variance in the SBPS, while depression symptoms alone (not semester nor symptoms of anxiety and stress) continued to predict significant unique variance in the DECE and DECI.

In summary, the findings from Sample 1 revealed there were no significant differences between OC users and non-users in terms of boredom proneness or flow. These patterns remained even when variance associated with the semester of data collection and depression, anxiety, and stress symptoms were statistically partialled out in regression analyses.

### 3. Sample 2

The purpose for analyzing data from Sample 2 was to determine whether the results of Sample 1 would replicate in an independent sample of undergraduate OC users and non-users.

#### 3.1. Method

##### 3.1.1. Participants

As in Sample 1, all participants were undergraduates who reported their sex as female and who completed the Mass Testing survey and Pre-screen questionnaire in exchange for partial course credit. Like in Sample 1, eligibility for the Pre-screen and Mass Testing surveys was enrolment in at least one undergraduate psychology courses at the University of Waterloo. We again aimed to collect data from as many participants as possible and applied our exclusion criteria following data collection. Exclusions were made using the same a priori determined exclusion criteria as Sample 1. The exclusion criteria, data cleaning and analysis code from Sample 1 were pre-registered as the data analysis plan for Sample 2 on OSF (<https://osf.io/f6xqa/overview>) prior to beginning the analyses for Sample 2. Exclusions (and Ns) are described in the Data Cleaning

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<sup>3</sup> The original regression analyses in this manuscript (for Sample 1, Sample 2, and the Combined Sample) included only the semester of data collection and DASS-Depression subscale as predictors in Step 1 of these regressions, followed by the addition of OC use in Step 2. These models are included in Supplementary Materials. Based on a suggestion of a reviewer, in the main manuscript we include analyses that control for all measures included in the DASS (depression, anxiety, and stress).

section below. We collected data from 1348 female participants in Fall 2022. We excluded 767 participants according to the exclusion criteria, resulting in 581 participants in Fall 2022, with 86 OC users and 495 non-OC users. In Winter 2023, we collected data from 1289 female participants of which 856 were excluded (375 participants who were part of Sample 1 and 155 individuals who participated in Fall 2022), leaving 433 participants (76 OC users and 357 non-users). In total, Sample 2 included 1014 participants with 162 OC users and 852 OC non-users who were also not using any other hormonal contraceptives. The mean age of OC users was 20.47 (SD = 2.74, range = 19-38). The mean age of non-OC users was 20.22 (SD = 2.27, range = 19-44).

### 3.1.2. Pre-screen and Mass Testing Surveys

In Sample 2, the Pre-screen and Mass Testing procedure was identical to Sample 1, with the exception that data was collected a year later at the beginning of two different semesters: Fall 2022 (September to October) and Winter 2023 (January to February). The items of the Pre-screen and Mass Testing (i.e., those used by other researchers for other studies) vary from semester to semester, but the main measures of interest were the same across semesters.

### 3.1.3. Data Cleaning

The data cleaning procedure was identical to Sample 1. In Fall 2022, we began with 1348 female participants. We first excluded 374 participants who were already included in Sample 1. We then excluded 18 participants because they used an IUD or hormonal contraceptive other than an OC. We also excluded 12 participants for copper IUD use, 48 for hormonal IUD use, and 58 participants for declining to respond to the item about hormonal birth control use. We excluded 148 participants (OC N = 60, non-OC N = 88) who reported currently receiving treatment for depression and 14 participants who did not disclose whether or not they were currently receiving depression treatment. Participants currently receiving treatment for anxiety were also removed (N = 60; OC N = 21, non-OC N = 39) as well as participants who did not report whether or not they were receiving treatment for anxiety (N = 6). Next, we checked for and excluded 26 participants with poor data quality. Data analyses were completed with and without exclusions based on age. This did not change the results in a meaningful way. The below analyses exclude 3 participants who were older than 45 to ensure our sample consisted of pre-menopausal females.

The Winter 2023 sample began with 1289 female participants. To ensure our samples were independent, we excluded 529 participants who were included in either Fall 2022 or the Sample 1 samples. Fifteen participants were removed for use of a hormonal contraceptive other than OC as well as 60 participants for use of an IUD (Copper N = 7; Hormonal N = 53). Fifty participants were excluded because they did not respond to the item inquiring about hormonal contraceptive use. We excluded 108 participants (OC N = 45, non-OC N = 63) currently receiving treatment for depression and 15 participants who did not respond to the item asking about depression treatment. We also excluded 45 participants because they were currently receiving treatment for anxiety as well as 3 participants who did not disclose whether or not they were receiving anxiety treatment. We also removed 27 participants for poor data quality. Post-hoc we removed 2 participants older than 45 and 2 participants who did not report their birth year to include participants within the reproductive age range. This did not meaningfully change the results.

Table 3. Regression model statistics for Sample 1

		<b>B</b>	<b>SE</b>	<b>p</b>
<b>DV: SBPS</b>		<b>R<sup>2</sup> = .321, F = 180.50, SE = 0.94, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	3.36	0.03	< .001
	Winter 2022	0.11	0.05	.029
	DASS-Dep	0.83	0.05	< .001
	DASS-Anx	0.03	0.06	.583
	DASS-Stress	0.01	0.06	.879
<b>Step 2</b>		<b>R<sup>2</sup> = .321, F = 144.40, SE = 0.94, Model p &lt; .001</b> <b>ΔR<sup>2</sup> = .000, p for ΔR<sup>2</sup> = .582</b>		
	Intercept	3.36	0.03	< .001
	Winter 2022	0.11	0.05	.028
	DASS-Dep	0.83	0.05	< .001
	DASS-Anx	0.03	0.06	.577
	DASS-Stress	0.01	0.06	.863
	OC status	-0.03	0.06	.582
<b>DV: DECE</b>		<b>R<sup>2</sup> = .045, F = 18.05, SE = 1.27, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	4.17	0.04	< .001
	Winter 2022	0.12	0.07	.064
	DASS-Dep	-0.26	0.07	< .001
	DASS-Anx	0.03	0.08	.744
	DASS-Stress	-0.16	0.08	.061
<b>Step 2</b>		<b>R<sup>2</sup> = .045, F = 14.43, SE = 1.27, Model p &lt; .001</b> <b>ΔR<sup>2</sup> = .000, p for ΔR<sup>2</sup> = .919</b>		
	Intercept	4.17	0.05	< .001
	Winter 2022	0.12	0.07	.064
	DASS-Dep	-0.26	0.07	< .001
	DASS-Anx	0.03	0.08	.745
	DASS-Stress	-0.16	0.08	.061
	OC status	0.01	0.08	.919
<b>DV: DECI</b>		<b>R<sup>2</sup> = .032, F = 12.70, SE = 1.19, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	4.09	0.04	< .001
	Winter 2022	0.05	0.06	.439
	DASS-Dep	-0.19	0.06	.003
	DASS-Anx	0.01	0.07	.945
	DASS-Stress	-0.14	0.08	.075
<b>Step 2</b>		<b>R<sup>2</sup> = .032, F = 10.19, SE = 1.18, Model p &lt; .001</b> <b>ΔR<sup>2</sup> = .000, p for ΔR<sup>2</sup> = .661</b>		
	Intercept	4.10	0.04	< .001
	Winter 2022	0.05	0.06	.435
	DASS-Dep	-0.19	0.06	.002
	DASS-Anx	0.01	0.07	.939
	DASS-Stress	-0.14	0.08	.078
	OC status	-0.03	0.07	.661

Note 1: DV = Dependent variable; SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = Depression, Anxiety, and Stress Scale – Depression Subscale, DASS-Anx = Depression, Anxiety, and Stress Scale – Anxiety Subscale, DASS-Stress = Depression, Anxiety, and Stress Scale – Stress Subscale

Note 2: Step 1 included semester of data collection and depression symptoms as predictors. In Step 2, OC use was added to the model.

Note 3. Semester and OC status are dummy coded. For semester, Fall 2021 is the reference group. For OC status, non-OC use is the reference group. The DASS variables were all centered.

### 3.1.4. Materials

The materials were identical to those used in Sample 1.

### 3.2. Results and Discussion

We again performed the analyses in R (R Core Team, 2017) with the same packages that were used to analyze data from Sample 1. Anonymized data and analysis scripts are available at <https://osf.io/f6xqa/overview>. We conducted the same analyses as we implemented in Sample 1, and these analyses were pre-registered on OSF (see link above). Similar to Sample 1, we compared OC users and non-users on the measures of boredom and flow proneness<sup>4</sup> and also utilized hierarchical regressions to assess whether OC use was associated with our measures over and above depression symptoms and the semester of data collection.

#### 3.2.1. Descriptive Statistics

Descriptive statistics for both the OC and non-OC groups are presented in Table 4. All scales showed high reliabilities, with Cronbach alphas of .82 or greater (Table 5). We also include Pearson correlations between the measures within each group in Table 5.

Table 4. Descriptive statistics of measures by semester and group for Sample 2

Semester	Group	Measure	N	Mean	SD	Skew	Kurtosis
Fall 2022	Non-OC group	SBPS	495	3.50	1.05	0.07	-0.61
		DECE	495	4.14	1.24	-0.01	-0.52
		DECI	495	4.02	1.19	0.17	-0.08
		DASS-Dep	495	1.01	0.76	0.70	-0.32
		DASS-Anx	495	1.02	0.72	0.59	-0.42
		DASS-Stress	495	1.17	0.69	0.40	-0.42
	OC group	SBPS	86	3.33	1.10	0.31	-0.49
		DECE	86	3.99	1.20	0.02	-0.44
		DECI	86	3.83	1.21	0.11	-0.51
		DASS-Dep	86	0.84	0.68	1.00	0.57
		DASS-Anx	86	0.93	0.78	0.80	-0.46
		DASS-Stress	86	1.20	0.71	0.25	-0.85
Winter 2023	Non-OC group	SBPS	357	3.65	1.10	-0.04	-0.68
		DECE	357	4.16	1.29	-0.03	-0.35
		DECI	357	4.15	1.25	-0.03	-0.40
		DASS-Dep	357	1.03	0.73	0.47	-0.55
		DASS-Anx	357	0.98	0.70	0.58	-0.32
		DASS-Stress	357	1.15	0.68	0.20	-0.65
	OC group	SBPS	76	3.04	0.93	0.88	0.56
		DECE	76	4.38	1.07	-0.16	-0.68
		DECI	76	4.17	1.13	-0.01	0.10
		DASS-Dep	76	0.76	0.58	0.68	-0.36
		DASS-Anx	76	0.74	0.60	0.97	0.27
		DASS-Stress	76	1.11	0.65	0.45	-0.54

Note. SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = DASS Depression Subscale, DASS-Anx = DASS Anxiety Subscale, DASS-Stress = DASS Stress Subscale.

<sup>4</sup> As in Sample 1, we also compared the OC and non-OC groups on symptoms of depression, anxiety, and stress. These analyses are included in the Supplementary Materials.

Table 5. Cronbach alphas (left panel) and Pearson correlations (right panel) of the OC group (above the diagonal; N = 162) and non-OC group (below the diagonal; N = 852)

Measure	OC Cronbach $\alpha$	Non-OC Cronbach $\alpha$	1	2	3	4	5	6
1. SBPS	.86	.85	--	-.36 **	-.39 **	.56 **	.46 **	.45 **
2. DECE	.96	.95	-.35 **	--	.42 **	-.26 *	-.34 **	-.26 *
3. DECI	.95	.94	-.28 **	.43 **	--	-.29 **	-.27 **	-.32 **
4. DASS-Depression	.87	.90	.54 **	-.23 **	-.16 **	--	.59 **	.67 **
5. DASS-Anxiety	.84	.82	.40 **	-.19 **	-.15 **	.70 **	--	.74 **
6. DASS-Stress	.84	.85	.48 **	-.22 **	-.18 **	.73 **	.80 **	--

Note. SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = DASS Depression Subscale, DASS-Anx = DASS Anxiety Subscale, DASS-Stress = DASS Stress Subscale. \*  $p = .05$ , \*\*  $p < .001$

### 3.2.2. Correlations

The results of both OC and non-OC groups again indicated that boredom proneness is negatively associated with flow proneness (the DECI and DECE), and positively correlated with symptoms of depression, anxiety, and stress. Flow proneness was negatively related to symptoms of depression, anxiety, and stress. Thus, the results of Sample 2 closely replicate the results of Sample 1 and further confirm the expected relations among the constructs measured.

### 3.2.3. Planned Comparisons

Boxplots depicting each of the measures as a function of OC use condition (averaged across semesters) are shown in Figure 2. To control for multiple comparisons, we utilized a Bonferroni correction, setting alpha at .017 (.05 / 3). When we collapsed across semesters, we found that OC users reported significantly less boredom proneness than non-users,  $t(232.9) = 4.16$ ,  $p < .001$ ,  $d = 0.35$ ,  $BF_{10} = 251.18$ . This comparison follows the same pattern of results found for boredom proneness in Sample 1 (though this comparison was not statistically significant in Sample 1). The Bayes Factor indicated there was extreme evidence for the alternative hypothesis. Also, as in Sample 1, there were no significant differences between groups on the DECE,  $t(239.3) = 0.25$ ,  $p = .807$ ,  $d = 0.02$ ,  $BF_{10} = 0.10$ , or DECI,  $t(230.5) = 0.87$ ,  $p = .387$ ,  $d = 0.07$ ,  $BF_{10} = 0.14$ . For these flow measures, Bayes Factors indicated there was moderate evidence for the null hypothesis.

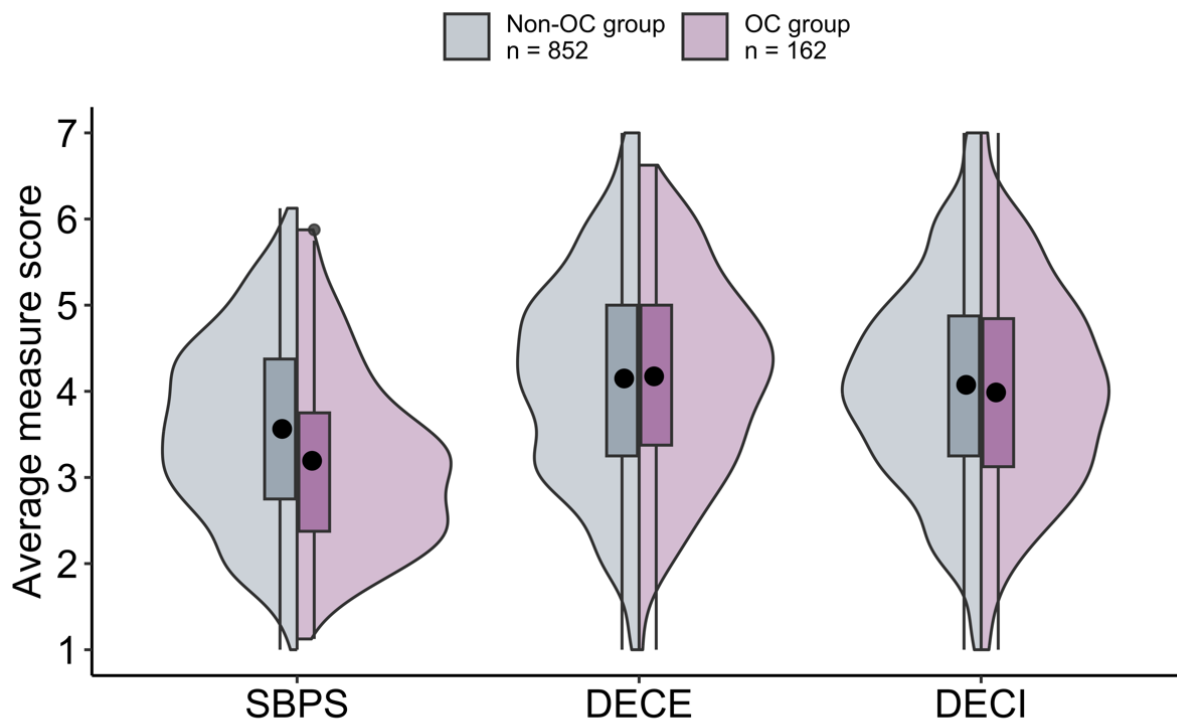
### 3.2.4. Regressions

To mirror our analyses of Sample 1 and to further investigate the differences in boredom proneness found in the present Sample, we conducted a series of hierarchical regressions predicting scores on our boredom and flow measures. We entered the semester of data collection and depression, anxiety, and stress symptoms (measured on the DASS) as predictors in Step 1 and then added OC use as a predictor in the second step (see Table 6).

In Step 1, the semester of data collection and depression, anxiety, and stress symptoms together accounted for an overall significant amount of variance in each dependent measure (SBPS:  $R^2 = .310$ , model  $p < .001$ , DECI:  $R^2 = .046$ , model  $p < .001$ , DECE:  $R^2 = .063$ , model  $p < .001$ ). When the unique variance explained by each measure was considered, predictiveness

varied across dependent variables. Depression and stress were unique predictors of boredom (measured by the SBPS), depression was the unique predictor of external flow (measured by the DECE), while stress and semester (Winter 2023) uniquely predicted internal flow (measured by the DECI).

Figure 2. Split violin plot with box and whisker plots (boxplots) for each of the measures (SBPS, DECE, and DECI) as a function of OC group (Non-OC vs. OC) in Sample 2



When OC use was added as a predictor in Step 2, predictiveness continued to vary across the dependent measures. Specifically, when boredom proneness was the dependent measure, the inclusion of OC use in Step 2 improved the model, with OC use, depression, and stress accounting for unique variance, although the addition of OC use explained a very small amount of additional variance ( $\Delta R^2 = .007$ ). Consistent with Sample 1, however, for external flow (indexed by the DECE) we found that the addition of OC use in the second step did not explain additional variance. In this step, depression continued to be the only predictor of unique variance. When predicting internal flow (indexed by the DECI) we found the addition of OC use in Step 2 did not explain additional variance; both semester of data collection and stress symptoms continued to be unique predictors of DECI as they were in Step 1 (see  $\Delta R^2$  in Table 6).

Table 6. Regression model statistics for Sample 2

		<b>B</b>	<b>SE</b>	<b>p</b>
<b>DV: SBPS</b>		<b>R<sup>2</sup> = .310, F = 113.50, SE = 0.90, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	3.47	0.04	< .001
	Winter 2023	0.08	0.06	.181
	DASS-Dep	0.62	0.06	< .001
	DASS-Anx	-0.02	0.07	.773
	DASS-Stress	0.27	0.07	< .001
<b>Step 2</b>		<b>R<sup>2</sup> = .317, F = 93.69, SE = 0.89, Model p &lt; .001</b> <b>ΔR<sup>2</sup> = .007, p for ΔR<sup>2</sup> = .002</b>		
	Intercept	3.51	0.04	< .001
	Winter 2023	0.08	0.06	.145
	DASS-Dep	0.60	0.06	< .001
	DASS-Anx	-0.04	0.07	.564
	DASS-Stress	0.31	0.07	< .001
	OC status	-0.25	0.08	.002
<b>DV: DECE</b>		<b>R<sup>2</sup> = .063, F = 16.86, SE = 1.20, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	4.12	0.05	< .001
	Winter 2023	0.07	0.08	.383
	DASS-Dep	-0.24	0.08	.002
	DASS-Anx	-0.10	0.09	.244
	DASS-Stress	-0.13	0.10	.175
<b>Step 2</b>		<b>R<sup>2</sup> = .063, F = 13.52, SE = 1.20, Model p &lt; .001</b> <b>ΔR<sup>2</sup> = .000, p for ΔR<sup>2</sup> = .640</b>		
	Intercept	4.13	0.05	< .001
	Winter 2023	0.07	0.08	.374
	DASS-Dep	-0.24	0.08	.002
	DASS-Anx	-0.11	0.09	.229
	DASS-Stress	-0.13	0.10	.201
	OC status	-0.05	0.10	.640
<b>DV: DECI</b>		<b>R<sup>2</sup> = .046, F = 12.13, SE = 1.18, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	3.99	0.05	< .001
	Winter 2023	0.16	0.08	.036
	DASS-Dep	-0.12	0.08	.124
	DASS-Anx	-0.00	0.09	.983
	DASS-Stress	-0.26	0.10	.008
<b>Step 2</b>		<b>R<sup>2</sup> = .047, F = 10.02, SE = 1.18, Model p &lt; .001</b> <b>ΔR<sup>2</sup> = .001, p for ΔR<sup>2</sup> = .215</b>		
	Intercept	4.01	0.05	< .001
	Winter 2023	0.16	0.08	.033
	DASS-Dep	-0.13	0.08	.093
	DASS-Anx	-0.01	0.09	.894
	DASS-Stress	-0.24	0.10	.014
	OC status	-0.13	0.10	.215

Note 1: DV = Dependent variable; SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = Depression, Anxiety, and Stress Scale – Depression Subscale, DASS-Anx = Depression, Anxiety, and Stress Scale – Anxiety Subscale, DASS-Stress = Depression, Anxiety, and Stress Scale – Stress Subscale

Note 2: Step 1 included semester of data collection and depression symptoms as predictors. In Step 2, OC use was added to the model.

Note 3. Semester and OC status are dummy coded. For semester, Fall 2021 is the reference group. For OC status, non-OC use is the reference group. The DASS variables were all centered.

#### 4. Combined Analyses

While there are advantages to separating the overall data set into two samples as we did above, there are also benefits to combining the data and analyzing them as a single sample. Specifically,

combining the data into a single sample has the advantage of 1) increasing statistical power to detect smaller effects and 2) allowing us to observe the overall outcome for effects that were inconsistent across samples. Accordingly, we combined the two samples and conducted the same analyses as were conducted on each sample individually. We were particularly interested in determining whether the difference in boredom proneness between OC users and non-users found to be statistically significant in Sample 2 and only numerically (but in the same direction) in Sample 1 would emerge as a statistically significant difference in the combined sample. Furthermore, although we did not find significant differences across OC users and non-users for internal or external flow proneness in either sample, we entertained the possibility that when the samples are combined into one large sample there might be sufficient statistical power to detect such differences. Moreover, since Sample 2 was a direct replication of Sample 1 (and recruited participants from the same population), the samples should be sufficiently similar to one another to justify combining them. The combined sample included all participants from Samples 1 and 2 who met the inclusion criteria resulting in a sample of 2548 participants, with 505 OC users and 2043 non-users.

#### 4.1. Results and Discussion

Analyses were performed in R (R Core Team 2017) using the same packages as in Samples 1 and 2. Anonymized data and scripts are available online at <https://osf.io/f6xqa/overview>.

#### 4.2. Descriptive Statistics

In the combined sample all scales had Cronbach alphas of .82 or greater (see Table 7), indicating high reliabilities. Pearson correlations between the measures (collapsed across all semesters) within each group are presented in Table 7.

Table 7. Cronbach alphas (left panel) and Pearson correlations (right panel) of the OC group (above the diagonal; N = 505) and non-OC group (below the diagonal; N = 2043)

Measure	OC	Non-OC	1	2	3	4	5	6
	Cronbach $\alpha$	Cronbach $\alpha$						
1. SBPS	.88	.87	--	-.36 **	-.32 **	.61 **	.45 **	.45 **
2. DECE	.96	.96	-.35 **	--	.47 **	-.27 **	-.25 **	-.27 **
3. DECI	.95	.95	-.30 **	.46 **	--	-.26 **	-.18 *	-.25 **
4. DASS-Depression	.90	.90	.54 **	-.20 **	-.15 **	--	.68 **	.71 **
5. DASS-Anxiety	.83	.82	.39 **	-.16 **	-.14 **	.68 **	--	.77 **
6. DASS-Stress	.84	.85	.43 **	-.18 **	-.16 **	.73 **	.78 **	--

Note. SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = DASS Depression Subscale, DASS-Anx = DASS Anxiety Subscale, DASS-Stress = DASS Stress Subscale. \*  $p = .05$ , \*\*  $p < .001$

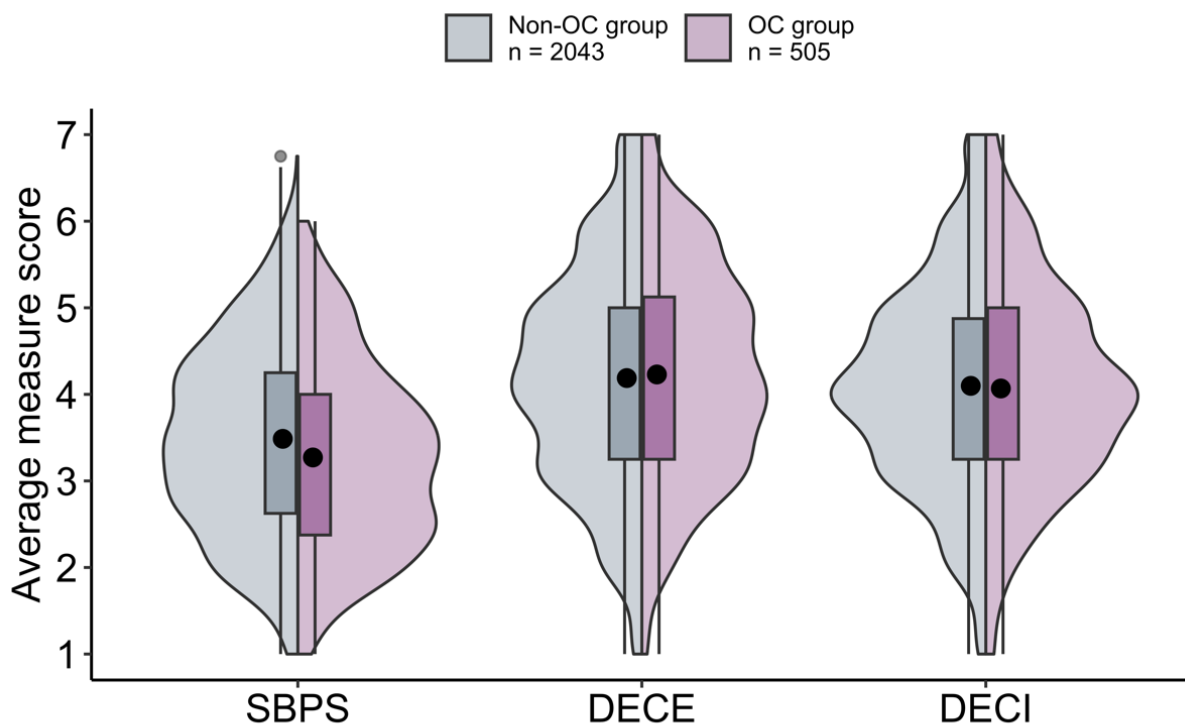
#### 4.3. Correlations

As in Samples 1 and 2, boredom proneness continued to be negatively associated with flow proneness (the DECI and DECE), and positively correlated with symptoms of depression, anxiety, and stress. Furthermore, flow proneness was again negatively related to symptoms of depression, anxiety, and stress.

#### 4.4. Planned Comparisons

Figure 3 shows the mean of each measure (SBPS, DECE, and DECI) as a function of OC use averaged across all semesters. To control for multiple comparisons, we utilized a Bonferroni correction, setting alpha at .017 (.05 / 3). When the data were collapsed this way, OC users reported significantly less boredom proneness (on the SBPS) than non-users,  $t(791.4) = 3.98$ ,  $p < .001$ ,  $d = 0.19$ , with the Bayes Factor indicating extreme evidence for the alternative hypothesis,  $BF_{10} = 102.71$ . The analyses also revealed no significant differences between OC users and non-users in their reports of external flow (DECE),  $t(797.02) = 0.67$ ,  $p = .502$ ,  $d = 0.03$ , or internal flow (DECI),  $t(779.8) = 0.51$ ,  $p = .609$ ,  $d = 0.03$ , with the Bayes Factors for external ( $BF_{10} = 0.07$ ) and internal ( $BF_{10} = 0.06$ ) flow indicating strong evidence for the null hypotheses.

Figure 3. Violin plot with box and whisker plots (boxplots) for each of the measures (SBPS, DECE, DECI) as a function of OC group (Non-OC vs. OC) collapsed across Samples 1 and 2



#### 4.5. Regressions

We again conducted regression analyses to examine whether OC use was associated with our boredom and flow measures over the above the semester of data collection and depression, anxiety, and stress symptoms. The semester and depression, anxiety, and stress symptoms were entered in the first step and OC use was added in the second step.

In Step 1, all three models predicting our measures of interest accounted for a significant amount of variance (SBPS:  $R^2 = .315$ , model  $p < .001$ , DECI:  $R^2 = .038$ , model  $p < .001$ , DECE:  $R^2 = .052$ , model  $p < .001$ ; see Table 8). In this step, depression and stress symptoms predicted unique variance in all measures, while both winter semesters (Winter 2022 and 2023) also

predicted unique variance in SBPS. Only Winter 2022 predicted unique variance in DECE, however no semester predicted unique variance in DECI.

When OC use was added in the second step, OC use only explained significant additional measures in boredom (measured by the SBPS) but did not explain significant additional variance in internal or external flow (measured by the DECI and DECE). Symptoms of depression and stress remained the only unique predictors of all measures. The Winter semesters continued to predict unique variance in SBPS, while semester did not predict unique variance in the DECI or DECE. However, while the addition of OC use in the second step did explain unique and additional variance in boredom, the amount of additional variance explained was small ( $\Delta R^2 = .001$ ).

Table 8. Regression model statistics for Combined Sample (Samples 1 and 2)

		<b>B</b>	<b>SE</b>	<b>p</b>
<b>DV: SBPS</b>		<b>R<sup>2</sup> = .315, F = 195.10, SE = 0.92, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	3.38	0.03	< .001
	Winter 2022	0.12	0.05	.016
	Fall 2022	0.04	0.05	.417
	Winter 2023	0.11	0.05	.037
	DASS-Dep	0.75	0.04	< .001
	DASS-Anx	0.01	0.04	.753
	DASS-Stress	0.12	0.05	.014
<b>Step 2</b>		<b>R<sup>2</sup> = .316, F = 168.10, SE = 0.92, Model p &lt; .001</b>		
		<b><math>\Delta R^2 = .001, p \text{ for } \Delta R^2 = .034</math></b>		
	Intercept	3.40	0.03	< .001
	Winter 2022	0.12	0.05	.014
	Fall 2022	0.03	0.05	.500
	Winter 2023	0.11	0.05	.044
	DASS-Dep	0.74	0.04	< .001
	DASS-Anx	0.01	0.04	.790
	DASS-Stress	0.12	0.05	.009
	OC status	-0.10	0.05	.034
<b>DV: DECE</b>		<b>R<sup>2</sup> = .052, F = 23.12, SE = 1.24, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	4.15	0.04	< .001
	Winter 2022	0.12	0.06	.061
	Fall 2022	-0.01	0.07	.938
	Winter 2023	0.07	0.07	.366
	DASS-Dep	-0.25	0.05	< .001
	DASS-Anx	-0.03	0.06	.621
	DASS-Stress	-0.15	0.06	.019
<b>Step 2</b>		<b>R<sup>2</sup> = .052, F = 19.81, SE = 1.24, Model p &lt; .001</b>		
		<b><math>\Delta R^2 = .000, p \text{ for } \Delta R^2 = .903</math></b>		
	Intercept	4.16	0.04	< .001
	Winter 2022	0.12	0.06	.061
	Fall 2022	-0.01	0.07	.932
	Winter 2023	0.07	0.07	.368
	DASS-Dep	-0.25	0.05	< .001
	DASS-Anx	-0.03	0.06	.619
	DASS-Stress	-0.15	0.06	.020
	OC status	-0.01	0.06	.903
<b>DV: DECI</b>		<b>R<sup>2</sup> = .038, F = 16.53, SE = 1.18, Model p &lt; .001</b>		
<b>Step 1</b>	Intercept	4.08	0.04	< .001
	Winter 2022	0.04	0.06	.485
	Fall 2022	-0.06	0.06	.316
	Winter 2023	0.10	0.07	.168

	DASS-Dep	-0.16	0.05	.001
	DASS-Anx	-0.00	0.06	.998
	DASS-Stress	-0.19	0.06	.002
<b>Step 2</b>	<b>R<sup>2</sup> = .038, F = 14.34, SE = 1.18, Model p &lt; .001</b>			
	<b>ΔR<sup>2</sup> = .000, p for ΔR<sup>2</sup> = .276</b>			
	Intercept	4.09	0.04	< .001
	Winter 2022	0.04	0.06	.475
	Fall 2022	-0.07	0.06	.284
	Winter 2023	0.09	0.07	.180
	DASS-Dep	-0.16	0.05	.001
	DASS-Anx	-0.00	0.06	.978
	DASS-Stress	-0.18	0.06	.003
	OC status	-0.06	0.06	.276

Note 1: DV = Dependent variable; SBPS = Boredom Proneness Scale – Short Form, DECE = Deep Effortless Concentration – External Scale, DECI = Deep Effortless Concentration – Internal Scale, DASS-Dep = Depression, Anxiety, and Stress Scale – Depression Subscale, DASS-Anx = Depression, Anxiety, and Stress Scale – Anxiety Subscale, DASS-Stress = Depression, Anxiety, and Stress Scale – Stress Subscale

Note 2: Step 1 included semester of data collection and depression symptoms as predictors. In Step 2, OC use was added to the model.

Note 3. Semester and OC status are dummy coded. For semester, Fall 2021 is the reference group. For OC status, non-OC use is the reference group. The DASS variables were all centered.

## 5. General Discussion

In the present investigation we explored the relations between OC use and the tendency to experience boredom and internal and external flow (defined as deep, effortless concentration). To examine these relations, we conducted a secondary analysis on a large data set collected across four semesters at an undergraduate institution, first splitting the data into two reasonably large samples, and then analyzing all the data as one large sample. While there were some differences in outcomes across samples, overall, our analyses suggest that OC users report lower levels of boredom proneness than do non-users and that there are no differences between groups in their self-reported experiences of flow. Bayes Factors supported this interpretation, demonstrating moderate to strong evidence for no differences in flow between groups. The difference in boredom proneness between OC users and non-users was statistically significant in Sample 2 and when the two samples were combined, but not in Sample 1. However, while these effects were small, Bayes Factors indicated ‘extreme evidence’ for a difference in boredom proneness between groups in Sample 2 and when Samples 1 and 2 were combined (while we found moderate evidence for no difference in boredom proneness between groups in Sample 1). Furthermore, regression analyses revealed that depression and stress were reliable predictors of both boredom and flow, and when depression, anxiety, stress, and semester of data collection were entered as predictors, OC use was a significant unique predictor of boredom only in Sample 2 and when the samples were combined, but not in Sample 1. However, we hasten to add that while the amount of additional variance in boredom explained by OC use was statistically significant, it was small (less than 1%). Overall, in the regression models, when the samples were combined, depression, anxiety, and stress symptoms, semester of data collection, and OC use accounted for ~32% of the variance in boredom proneness, which suggests moderate explanatory value. These variables only account for ~4% and ~5% of the variance in internal and external flow, suggesting that they have weak explanatory value for flow experience. Overall, these results suggest that OC use associated with fewer experiences of boredom, even once we control

for the semester of data collection and symptoms of depression, anxiety, and stress, although this effect is quite small.

These findings extend prior work that examined the link between hormonal contraceptive use and cognition (see Gurvich et al., 2023 for a review) and particularly studies of OC-use and aspects of attention (Raymond et al., 2019; Smith et al., 2023). Early findings in the domain of attention suggested that OC use might be associated with increased inattention in the form of mind wandering (Raymond et al., 2019). If interpreted in a causal way, these findings would suggest that OC use is concerningly detrimental to attention. However, as noted earlier, in one sample Smith et al. (2023) found that OC use was associated with a lower propensity to experience spontaneous and deliberate mind wandering as well as fewer attention related errors (i.e., better everyday attention) but these effects did not replicate in a second independent sample, which showed no significant differences between OC users and non-users. More consistent with Smith et al. (2023) than with Raymond et al. (2019) we find no significant differences between OC users and non-users in terms of the propensity to experience internal and external flow, and *lower* levels of boredom in OC users than non-users. Thus, our work suggests that OC use might be associated with either no changes in attention, or perhaps very modest improvements in some attention-related domains (e.g., boredom). However, we remind the reader that the extant relations are correlational, and more work is needed to understand the mechanism behind this effect.

Our observed relation between OC use and boredom proneness underscores the importance of collecting data from large samples and accounting for third variables (e.g., depression). Many studies examining OC use and attention as well as cognition (more generally) have small groups of OC users—that is, OC groups containing 35 or fewer participants (see Tables 1–10 in Gurvich et al., 2023). As Beltz (2022) notes in her review of the literature examining OC use and cognition, at least 64 OC users (and 64 non-users in a comparison group) are necessary to detect moderate-sized effects (Faul et al., 2007). This means many (if not most) studies investigating the relation between OC use and cognition have been under-powered to detect medium and small effect sizes and may contribute to the inconsistent results across studies. Moreover, few studies account for third variables such as depression symptoms which are known to vary with both OC use and cognitive performance (e.g., Hamstra et al., 2017; McDermott & Ebmeier, 2009; Seli et al., 2019; Skovlund et al., 2016). By controlling for these potential confounds in statistical analyses (such as hierarchical regressions), we can better understand whether the cognitive effects we observe are attributable to OC use and/or the third variables measured. For example, in the present study, we were able to tease apart the unique relation between OC use and boredom while controlling for symptoms of depression, anxiety, and stress, and the semester of data collection.

Consistent with prior theoretical conjectures (e.g., Csikszentmihalyi, 2000; Weibel & Wissmath, 2024) we found that boredom proneness and flow were negatively correlated. While this is consistent with the notion that boredom and flow are opposite experiences that exist on a single continuum and are perhaps driven by the same underlying neural mechanism, several aspects of our data are inconsistent with this conclusion. First, the negative relation between boredom and flow in our samples was relatively modest suggesting related but distinct constructs. Second, while we found boredom to be associated with OC use, this was not the case for flow.

Further research will be needed to more fully distinguish boredom and flow and to describe the unique mechanisms underlying each of these states.

While we did not observe a relation between OC use and flow experience in the present studies, we are hesitant to conclude from the present studies that this relation does not exist. Here, we defined flow as deep effortless concentration (Marty-Dugas & Smilek, 2019), however, this is not the only operationalization of flow experience (Csikszentmihalyi & Csikszentmihalyi, 1988; Jackson & Eklund, 2002; Jackson & Marsh, 1996; Jackson et al., 2001; Macbeth, 1988; Nakamura & Csikszentmihalyi, 2002). Other operationalizations of flow experience take into account more peripheral aspects (e.g., skill challenge balance, loss of self-consciousness, heightened sense of control, intrinsic reward [Csikszentmihalyi & Csikszentmihalyi, 1988; Jackson & Eklund, 2002; Jackson & Marsh, 1996; Jackson et al., 2001; Macbeth, 1988; Nakamura & Csikszentmihalyi, 2002]). So, while we find no evidence that OC use is related to deep effortless concentration, it is possible that OC use is related to those more peripheral aspects of flow.

Lastly, this work suggests several future directions. First, this study utilized secondary data that did not include details about participants' current or historical OC use (e.g., the brand of OCs used, length of use, whether non-users had used OCs in the past and if so, for how long). Different brands of OCs have different combinations of exogenous (or artificial) estrogen and progesterone (by dose, dose schedule, and composition). Some work has shown that collapsing across different types of OCs may mask effects specific to different doses, dosing schedules, and/or compositions (e.g., Beltz et al., 2015; Wharton et al., 2008). However, given the power problems present in much of the work examining OC use and cognition we noted earlier, it is worth considering that splitting the OC group into these OC sub-groups may bring statistical power to problematically low levels. Nevertheless, future work could examine flow and boredom proneness in either as a function of OC type and/or in more homogeneous OC users to better understand how these differences may contribute to attention. Second, given that the present studies examined the relation between OC use and the trait-level tendencies to experience boredom and flow, future work could also examine whether OC use is also associated with differences in boredom and flow at the state-level during a cognitive task. Studies such as these will bring us closer to a more complete understanding of the relations between OC use and various cognitive functions.

### **Author Contributions**

ACS was responsible for conceptualization, formal analysis, methodology, visualization, writing—original draft and writing—review, and editing. JMD was responsible for conceptualization, methodology, and writing—review and editing. DS was responsible for conceptualization, methodology, supervision, and writing—review and editing. A version of this manuscript was a chapter in Alyssa Smith's dissertation.

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