

**THE EFFECTS OF ORAL CONTRACEPTIVE USE ON OBJECTIVE AND
SUBJECTIVE EPISODIC MEMORY**

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ABSTRACT

Introduced more than 60 years ago, oral contraceptives (OC) are one of the most common forms of contraceptives used by reproductive-aged women today. Despite their widespread use, very little is known about the ways in which the hormones contained in OCs (i.e., synthetic versions of estradiol and progesterone) affect cognition, with much of the literature having been criticized for its predominance of cross-sectional designs, inconsistent consideration of OC-related factors (e.g., pill formulation, reproductive history/previous hormonal contraceptive use, group heterogeneity, etc.), and variable characterization and measurement of cognitive domains. Some studies have suggested that OC use may slightly enhance verbal episodic memory (i.e., our long-term, explicit recollection of personal events), although findings are mixed. It also remains unclear whether OC use alters subjective perceptions of one's memory.

Across three studies, this dissertation addresses the extent to which OC use might influence objective and subjective memory. I begin by describing the development and validation of the neuropsychological methods used in the second half of this thesis. Next, I cross-sectionally examine differences in subjective and objective memory between OC users and non-users. Finally, this thesis culminates with a quasi-experimental, repeated-measures investigation of objective and subjective memory changes in newly initiated OC users.

We first tested the reliability of the Multifactorial Memory Questionnaire (MMQ)—a widely-used measure of subjective memory—for use with healthy young adults. Confirmatory factor analysis (CFA) with age invariance testing conducted with $n = 408$ young and $n = 327$ older adults suggested that although the MMQ is more reliable in older adults, it is also adequate for use in younger populations. Next, we piloted the remotely-administered, web-based implementation of a well-established episodic memory battery in $n = 50$ young adults and

checked the feasibility of two parallel battery versions for repeated online testing. Additionally, using (young female participant only) data from a previous study employing a similar web-based battery, CFA was used to verify relationships between individual memory tasks in the battery and replicate its factor structure.

The final study employed the measures verified above to systematically investigate the role of OC use in objective and subjective memory while addressing common methodological limitations in the literature. Cross-sectional analyses revealed slightly higher objective memory and memory satisfaction among OC users ($n = 60$) compared to non-users ($n = 75$); these results were also dependent on parallel task version and participants' first language. Repeated measures analyses assessing group-by-time interactions, however, indicated no significant changes in objective or subjective memory in newly initiated OC users ($n = 37$) following three months/cycles of use, compared to long-time OC users ($n = 43$) and non-users ($n = 45$).

Findings from the present dissertation shed light on the existing mixed evidence on the involvement of OCs in cognitive functioning and suggest that influences on memory may emerge following more prolonged exposure to OC hormones. Notably, this thesis also provides preliminary support for a possible role of contraceptives in subjective memory, particularly satisfaction with everyday memory functioning. Potential implications of our findings for the growing field of contraceptives and cognition research, including methodological considerations, underlying mechanisms of OC influences on cognition, and future research directions are discussed.

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CONTRIBUTIONS OF AUTHORS

Study 1: Multifactorial Memory Questionnaire: A comparison of young and older adults

A.J., A.W.C., and P.S.R.D. conceived and designed the study. A.J. collected, scored, processed, and analyzed the data, and drafted the original manuscript. P.S.R.D., H.D., S.R., M.E.B.G., and V.S. contributed to data collection for the archival dataset. R.H. assisted with data scoring and processing. All co-authors reviewed and revised the manuscript.

Study 2: The development of a remotely administered episodic memory battery for repeated use (Pilot study)

A.J. and P.S.R.D. conceived and designed the study. A.J. collected, scored, and analyzed the data, and drafted the original manuscript. P.S.R.D. reviewed and revised the manuscript.

Study 3: Effects of oral contraceptive initiation on objective and subjective episodic memory: Cross-sectional and longitudinal data

A.J. and P.S.R.D. conceived and designed the study. A.J. collected, scored, and analyzed the data, and drafted the original manuscript. N.Z. (undergraduate student) assisted with scoring a portion of the data. P.S.R.D. reviewed and revised the manuscript.

ABBREVIATIONS

4MT	Four Mountains Task
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BLT	Brown Location Test
CES-D	Center for Epidemiological Studies Depression Scale
CESD-10	Center for Epidemiological Studies Short Depression 10-item scale
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
CNS	Central nervous system
cOC	Current oral contraceptive users
EE	Ethinyl estradiol
ER	Estrogen receptor
fMRI	Functional magnetic resonance imaging
FNPA	Face-Name Paired Associates
FSH	Follicle-stimulating hormone
GMV	Gray matter volume
HC	Hormonal contraceptive
HPA	Hypothalamic-pituitary-adrenal axis
HPG	Hypothalamic-pituitary-gonadal axis
ICC	Intraclass correlation coefficient
ISPR	Integrated System of Participation in Research
IUD	Intrauterine device
LH	Luteinizing hormone
LLM	Large language model
MMQ	Multifactorial Memory Questionnaire
MoCA	Montreal Cognitive Assessment
MRI	Magnetic resonance imaging
MTL	Medial temporal lobes
NC	Naturally cycling participant
newOC	New oral contraceptive users
OA	Older adults
OC	Oral contraceptives
PANAS	Positive and Negative Affect Schedule
PCOS	Polycystic ovary syndrome context

PFC	Prefrontal cortex
PMDD	Premenstrual dysphoric disorder
RCT	Randomized controlled trial
RMSEA	Root mean square error of approximation
SD	Standard deviation
SRMR	Standardized root mean square residual
TLI	Tucker-Lewis index
TIPI	Ten-Item Personality Inventory
VPA	Verbal Paired Associates
WCST	Wisconsin Card Sorting Test
WMS	Wechsler Memory Scale
YA	Young adults

1. Chapter I – General Introduction

Over the last few decades, the effects of ovarian sex steroids on the brain have begun to receive the long-overdue attention of researchers. So far, most work in this domain has focused on hormonal fluctuations across the menstrual cycle (Le et al., 2020; Sundström-Poromaa, 2018), sex hormone administration in animal models (Porcu et al., 2019), and hormone replacement therapy in peri- and postmenopausal females¹ (Hogervorst et al., 2000; Zhou et al., 2020). The invention of oral contraceptives (OC), in particular, marked a unique opportunity to study the neural effects of exogenous hormones in young, premenopausal individuals, allowing us to better understand how sex hormones (or lack thereof) interact with the brain. However, despite their well-established widespread use today, OCs remain understudied, particularly with respect to their potential role in cognition.

Today, OCs are the second most prescribed form of hormonal contraception (after the intra-uterine device; IUD), used by more than 150 million individuals worldwide (United Nations, 2022). In Canada, approximately 16% of women aged 15-49 years have reported using OCs in the previous month (Statistics Canada, 2015). According to available data, OC use is most popular among women aged 15-24 years (U.S. Department of Health & Human Services 2015-2017 data) and is the method of choice of 25% of individuals currently using contraceptives (Cooper & Patel, 2025). Although their most common reason for use is to protect against pregnancy, OCs are also often taken for non-contraceptive reasons, such as managing menstrual pain and disorders (Cooper & Patel, 2025).

¹ Sex and gender: In the present thesis, I follow the Canadian Institutes of Health Research (CIHR) guidelines for integrating sex and gender into research (<https://cihr-irsc.gc.ca/e/50836.html>), using the terms “male” and “female” to describe the biological sex (at birth) of human research participants. These are distinct from the terms “man” and “woman”, which refer to the gender of participants (i.e., related to individuals’ sociocultural identities and roles).

OC use has been claimed to influence various cognitive domains including but not limited to episodic memory and executive control (for reviews, see Beltz, 2022; Gurvich et al., 2023; Hampson, 2023; Taylor et al., 2021; Warren et al., 2014). However, notable limitations in the extant literature have prevented researchers from understanding the full scope of OC effects on cognition (see [Section 1.2.6](#); Beltz & Moser, 2020; Taylor et al., 2021; Warren et al., 2014). In fact, people have been using OCs for the past six decades without fully understanding how these drugs might affect their brain and behaviour. This general lack of knowledge surrounding OCs is just one of many reasons why they should be studied today: Firstly, since their introduction to the market in the 1960s, their hormonal formulations have changed drastically (Christin-Maitre, 2013; Dhont, 2010; Golobof & Kiley, 2016), thus findings from older studies do not necessarily apply to today (see Hampson, 2023). Additionally, any psychological findings from high-quality OC studies have implications for the everyday lives of OC users (see Hampson, 2023). Although it has been argued that the effects of OCs are domain specific, many previous studies have examined their effects on global cognition (Hampson, 2018b). Therefore, studies examining specific cognitive domains, such as episodic memory, are especially needed.

Given their widespread usage, OCs present a valuable opportunity to study the effects of sex hormones on cognition and are also an important target of research themselves. In this dissertation, I aim to contribute to our knowledge of the effects of OCs on cognition by asking about the degree to which initiation of OC use might influence both objective and subjective (i.e., self-reported) episodic memory in young adults.

1.1 Sex hormones and the CNS

To appropriately address the present research question, it is important to first understand how the endogenous (i.e., naturally occurring) sex steroids estrogen and progesterone influence

the female brain. Estrogen is an umbrella term for the hormones estradiol, estrone, and estriol—estradiol being the most potent and biologically active of the three in premenopausal individuals (Gogos et al., 2013; Jeyakumar et al., 2011). Traditionally, these hormones have been studied in the context of behavioural sex differences (e.g., Gurvich et al., 2018; McEwen & Milner, 2017), and only within the last few decades have researchers begun to examine the behavioural correlates and outcomes of hormonal variability related to the menstrual cycle or hormonal contraceptive (HC) use, which have offered a more nuanced understanding of the effects of female sex steroids in the central nervous system (CNS).

In the following sections, I synthesize what is currently known about the main sex steroids estradiol and progesterone. I begin with an overview of the human menstrual cycle, which will be relevant to understanding both the actions of sex steroids and the mechanisms of OCs in the CNS, especially considering that most OC studies employ naturally cycling participants as controls.

1.1.1 The menstrual cycle

The menstrual cycle is characterized by fluctuating concentrations of estradiol and progesterone controlled by the hypothalamic-pituitary-gonadal (HPG) axis. The HPG axis functions on a hormonal feedback loop, wherein the hypothalamus releases gonadotropin-releasing hormone, which stimulates the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the anterior pituitary, which in turn cause the ovaries to release estradiol and progesterone. These sex steroids then travel back to the hypothalamus to inhibit the production of gonadotropin-releasing hormone, thus fulfilling the negative feedback loop (Dwyer & Quinton, 2019).

The menstrual cycle is typically 28 days long ($SD = 3.5$ days) but can range anywhere from 21 to 35 days (Creinin et al., 2004; Mumford et al., 2012). It can be divided into three phases corresponding to distinct hormonal profiles: menses (days 1-5), follicular (days 6-14), and luteal (days 15-28). During the menses phase, levels of estradiol and progesterone drop, causing the uterus to shed its lining, resulting in menses. During this time, the pituitary releases FSH in response to low hormone levels which causes the ovaries to begin growing new follicles, marking the beginning of the follicular phase. The follicular phase is characterized by low progesterone levels and a steady increase in estradiol levels as the follicle grows. Around day 14 (i.e., mid-cycle), estradiol peaks, triggering the release of LH from the pituitary, which causes ovulation. The empty follicle (or *corpus luteum*) secretes estradiol and progesterone to prepare for pregnancy; these hormones reach their peak midway through the luteal phase while LH and FSH levels decrease. If fertilization does not follow, the *corpus luteum* breaks down and levels of ovarian hormones drop, and the cycle restarts with menstruation.

1.1.2 Mechanisms of action

Endogenous sex steroids influence the brain across the female lifespan by exerting both organizational and activational effects in the CNS (Hara et al., 2015; Barth et al., 2015; Galea et al., 2017). Organizational effects take place during important brain development periods and trigger hormonal transitions such as puberty. In contrast, activational effects are temporary changes occurring during adulthood, and are influenced by levels of circulating steroid hormones in the bloodstream during brain development, such as fluctuations in estradiol and progesterone across the natural menstrual cycle.

Estrogen and progesterone receptors are expressed widely throughout the brain (Almey et al., 2015; Brinton et al., 2008; Rossetti et al., 2016; for a review, see McEwen et al., 2012).

Estradiol's actions in the CNS are mediated by two main subtypes of estrogen receptors (ER), namely ER α and ER β . Although their distributions differ slightly, both subtypes are expressed in the prefrontal cortex (PFC), hippocampus, amygdala, and hypothalamus, among other areas (Almey et al., 2015; Gillies & McArthur 2010; Hara et al., 2015). Notably, both animal and human studies have shown that the expression of ER β is more abundant than ER α in the hippocampus (Österlund et al., 2000; Shughrue et al., 1997; Zhang et al., 2002), a region crucial for episodic memory and spatial processes. The primary functions of ER α and ER β in the CNS may also be somewhat distinct: While ER α is involved in reproductive functions, ER β may play a more prominent role in memory and cognition more broadly (Österlund et al., 2000; Shughrue et al., 1997). A recent systematic review reported that estradiol interacts with ERs to regulate hippocampal synaptic plasticity and enhance long-term memory consolidation through the interplay of several mechanisms, including functional, structural, and signaling changes at the molecular level (Finney et al., 2020). According to animal studies, progesterone receptors have been found in numerous regions in the brain, including the hippocampus, PFC, amygdala, hypothalamus, thalamus, cerebellum, and more (Brinton et al., 2008; Pluchino et al., 2006), and their expression in many of these areas is influenced by estradiol (Bali et al., 2012; Zuloaga et al., 2012).

Sex steroids exercise their activational effects on the CNS via genomic (i.e., binding to different nuclear steroid receptors and altering gene transcription, leading to slow yet long-lasting effects) and non-genomic (i.e., binding to membrane-associated steroid receptors and activating signalling pathways, leading to more rapid effects that are shorter in duration) mechanisms (Barth et al., 2015; Luine, 2014; McEwen & Milner, 2017). In the longer term, estradiol can stimulate neurogenesis and alter regional brain volumes, potentially leading to

observable structural, functional, and/or behavioural changes. In the shorter term, by binding to membrane receptors, estradiol can affect different neurotransmitter systems involved in cognition (e.g., acetylcholine, glutamate, dopamine, serotonin; Barth et al., 2015; Mennenga et al., 2015) either by regulating the synthesis, reuptake, and breakdown of neurotransmitters, or by altering the expression of their receptors (McEwen & Woolley, 1994). Classical animal studies have shown that the administration of estradiol can exert neurotrophic effects on regional brain structure (particularly the PFC and hippocampus) by increasing synapse density and spine formation via both genomic and rapid, non-genomic actions (Hara et al., 2015; Leranth et al., 2008; McEwen & Alves, 1999; Tang et al., 2004; Tuscher et al., 2016; Woolley & McEwen, 1993). Notably, estradiol has been shown to modulate hippocampus-dependent memory and to enhance hippocampal synaptic plasticity through long-term potentiation (LTP), a cellular mechanism that supports long-term memory formation (for a review, see Smith et al., 2009).

Estradiol is often studied in tandem with progesterone, as these hormones interact in the CNS and often work together to influence neural outcomes (Hara et al., 2015). Although its mechanisms of action are less well understood than those of estradiol, progesterone may also exert noteworthy effects on the CNS, including by influencing neural growth, synaptogenesis, and neurotransmitter signalling in brain regions involved in cognition (for systematic reviews, see Pletzer et al., 2023b; Toffoletto et al., 2014). Furthermore, some evidence has linked levels of gonadotropins LH and FSH to human cognition (Blair et al., 2015; Koebele et al., 2017), although their effects are not yet well understood and fall outside the scope of the current thesis.

1.1.3 Effects on brain structure and function

Through the mechanisms described above, fluctuations in ovarian steroid concentrations across the menstrual cycle have been linked to regional alterations in the hippocampus and

surrounding medial temporal lobes (MTL), a region crucial for episodic memory (for systematic reviews, see Dubol et al., 2021; Ruehr et al., 2025). Magnetic resonance imaging (MRI) studies have demonstrated increases in hippocampal grey matter volume (GMV) in high-estradiol (i.e., late-follicular/pre-ovulatory) compared to low-estradiol (i.e., late-luteal/early follicular) phases of the menstrual cycle (Barth et al., 2016; Lisofsky et al., 2015; Protopopescu et al., 2008). In addition to volumetric changes, Lisofsky et al. (2015) observed bilateral increases in functional connectivity between the hippocampus and the parietal lobe during the high-estradiol (i.e., late follicular) phase, indicating that estradiol may play a role in regulating both hippocampal volume and activity. Additionally, recent dense sampling MRI studies observed changes in hippocampal/MTL volume across the menstrual cycle which were associated with ovarian steroid concentrations (Heller et al., 2024; Taylor et al., 2020; Zsido et al., 2023).

Beyond the hippocampus, some studies have reported relationships between menstrual cycle phase and volume of brain regions involved in emotional processing, including the amygdala and insular cortex (De Bondt et al., 2016; Ossewaarde et al., 2011). While Ossewaarde et al. observed larger amygdala volumes during the late luteal phase than the late follicular phase, De Bondt et al. observed larger insula volumes during the ovulatory phase than the luteal phase.

Functional neuroimaging research has also uncovered some important links between endogenous ovarian steroids and neural activity. A systematic review of menstrual cycle studies reported that hormonal fluctuations across the menstrual cycle influenced brain activity in regions involved in executive control and emotional processing, such as the PFC, amygdala, and anterior cingulate cortex (Toffoletto et al., 2014). Distinct activation patterns in the follicular versus luteal phases were observed in such areas, and the authors noted that exogenous

hormones, such as OCs, may play a key role in altering neural function (see [Section 1.2.2](#)).

Supporting this, a recent dense-sampling functional MRI (fMRI) study observed that functional brain connectivity was associated with hormonal fluctuations across the menstrual cycle, with estradiol exerting an overall enhancing effect and progesterone having a reducing effect on connectivity and communication between brain regions (Pritschet et al., 2020).

1.1.4 Effects on cognition

Alterations in the size and function of different brain regions or networks caused by changes in endogenous ovarian steroids may be connected to alterations in cognition and behaviour. Our knowledge surrounding such outcomes in humans stems in part from research on sex differences in cognition. Sex differences have been reported in several cognitive areas, but most reliably in episodic memory (i.e., one's long-term, explicit recollection of past personal experiences; Asperholm et al., 2019) and verbal abilities (Hampson, 2002; Hirnstein et al., 2023). Some studies have also identified sex differences on some aspects of executive control; however, these effects are smaller and less consistent than those observed in other domains (Gaillard et al., 2021). Relatedly, there is ample evidence supporting the role of endogenous sex steroids in cognitive sex differences (Gurvich et al., 2018; McEwen & Milner, 2017). Menstrual cycle studies, for instance, have recognized that fluctuations in estradiol and progesterone across the normal menstrual cycle can induce rapid (i.e., within days) changes in brain structure and function (Heller et al., 2024; Pritschet et al., 2020; Zsido et al., 2023), and contribute to differences in performance in cognitive domains that typically show sex differences (e.g., Hampson, 1990; Hampson & Morley, 2013). In the following sections, I summarize the research on the associations of ovarian steroids with episodic memory and executive control.

1.1.4.1 Episodic memory

In adulthood, females typically demonstrate an advantage over males in episodic memory (Herlitz & Lovén, 2013; Herlitz & Rehnman, 2008; Kramer et al., 1988; for a comprehensive review, see Andreano & Cahill, 2009; for meta-analyses, see Asperholm et al., 2019; Hirnstein et al., 2023). This effect has been attributed to various interacting biological and sociocultural factors including but not limited to differences in verbal abilities and processing and the neuroprotective effects of estradiol (as discussed in Asperholm et al., 2019). The sex difference in episodic memory is especially pronounced on tasks involving verbal materials, or in which the material can be remembered using verbal strategies (e.g., concrete objects), with several reports of females outperforming males on story recall (Davis et al., 2015), word list recall (Weiss et al., 2003), verbal paired associates (Geffen et al., 1990; Talboom et al., 2019), and object location memory (Asperholm et al., 2019; Silverman et al., 2007). Females also often demonstrate better face recognition and memory than males (Asperholm et al., 2019; Herlitz & Lovén, 2013), which may be related to their preferential usage of verbally mediated strategies to encode faces (Lewin et al., 2001). According to a recent meta-analysis, the female advantage is small-to-moderate in both verbal episodic recall ($d = .28$) and recognition ($d = .12-.17$) (Hirnstein et al., 2023).

Estradiol has been argued to further modulate verbal episodic memory through its neuroprotective effects (Frick, 2015; Luine, 2014; Luine & Frankfurt, 2013; Phillips & Sherwin, 1992; Rentz et al., 2017; Sherwin, 2005). For instance, studies examining episodic memory across the natural menstrual cycle have generally reported better performance during high-estradiol phases (e.g., Hussain et al., 2016; Phillips & Sherwin, 1992; Sajadian et al., 2021). In one study, individuals tested during the midluteal phase, when estradiol and progesterone typically reach their peak, had better verbal memory scores than those tested during the menstrual phase, when estradiol and progesterone are at their lowest (Phillips & Sherwin, 1992).

Similarly, poorer memory (i.e., immediate and delayed word list recall) has been observed during the follicular phase, which is characterized by low estradiol and progesterone, compared to the ovulatory (Hussain et al., 2016; Sajadian et al., 2021) and midluteal phases (Hussain et al., 2016). Conversely, other menstrual cycle studies have reported null effects (Gogos, 2013; Hatta & Nagaya, 2009; Lisofsky et al., 2015; Maki et al., 2002; Mihalj et al., 2014; Mordecai et al., 2008).

On its own, progesterone may also influence memory, although its exact role is not yet fully understood (Barros et al., 2015). It should also be noted that although many sex hormone studies have been criticized for their small participant samples and flawed experimental designs (see [Section 1.2.6](#)), the consensus in the animal and human literatures is that estradiol generally contributes to enhanced learning and memory (see Luine, 2014).

1.1.4.2 Executive control

More controversial than the case of episodic memory is that of executive control. Highly related to the concepts of executive function, cognitive control, and attentional control, executive control preferentially recruits the PFC (Alvarez & Emory, 2006; McCabe et al., 2010). No reliable sex differences in executive control in young adults have been reported in the literature (Gaillard et al., 2021; Grissom & Reyes, 2019). However, in human neuroimaging research, males and females might differ in the neural networks recruited by executive control tasks (Gaillard et al., 2021).

Estradiol, which has many receptors in, and can even be synthesized in, the PFC (Hara et al., 2015), has been argued to influence cognitive functions mediated by this brain region. Among naturally cycling females, performance on PFC-dependent cognitive tasks, such as those measuring inhibitory control and working memory, may improve during periods of high estradiol

levels (Colzato et al., 2012; Hampson & Morley, 2013; Hatta & Nagaya, 2009; Jacobs & D'Esposito, 2011; Maki et al., 2002; Rosenberg & Park, 2002; for a review, see Sundström Poromaa & Gingnell, 2014). For instance, higher levels of circulating estradiol in naturally cycling females have been positively associated with verbal fluency (Maki et al., 2002). Meta-analyses have also reported a small but stable female advantage in (letter) verbal fluency (Hirnstein et al., 2023; Schultheiss et al., 2021), and this effect has been argued to be associated with estradiol levels (Hampson, 1990; Maki et al., 2002; Schultheiss et al., 2021).

Other studies have reported associations between periods of high circulating estradiol and better verbal working memory (Rosenberg & Park, 2002) and Stroop performance (Hatta & Nagaya, 2009). Similarly, Hampson and Morley (2013) reported that females tested during the high-estradiol phase of the menstrual cycle had better spatial working memory accuracy than females tested during low-estradiol phases and males. Other studies found no significant effect of menstrual cycle phase or circulating steroid levels on tasks of attention (Mordecai et al., 2008), verbal fluency (Mihalj et al., 2014; Mordecai et al., 2008), or working memory (Mihalj et al., 2014).

In sum, the literature shows that fluctuations in endogenous ovarian steroids, especially estradiol, can significantly contribute to episodic memory and aspects of executive control in naturally cycling individuals, with enhancing effects observed during high-hormone phases. Although the literature is sparser, analogous findings regarding the cognitive correlates of high-versus low-hormone phases have been observed in OC users in active versus inactive pill phases. Before covering those findings, I first review the actions and mechanisms of OCs in the CNS below.

1.2 Oral contraceptives and the CNS

The hormones contained in OCs alter the natural menstrual cycle and, given their structural similarity to endogenous sex steroids, may influence the brain and cognition. Currently, there exist over 100 individual brands of OC pills differing in their hormonal composition, dosage, and phasic regimen (i.e., mono- vs multi-phasic; Taylor et al., 2021). The potential effects of OCs may therefore vary considerably based on such factors, making this area of study rather complex.

OCs are available as either combined or progestin-only formulations. Progestin-only OCs, also known as the “minipill”, are devoid of estrogen and are therefore typically prescribed to individuals who may be sensitive to estrogen or have contraindications to combined formulations, such as those who have recently given birth or have particular medical conditions (e.g., blood clots, high blood pressure; Curtis et al., 2016). Combined OCs are more widely prescribed than the minipill. Besides the few formulations containing estradiol valerate or mestranol, most modern combined OCs contain ethinyl estradiol (EE) and one of several progestins, which are synthetic forms of estradiol and progesterone, respectively (Pletzer & Kerschbaum, 2014). Although EE and progestins may have separate, independent effects in the CNS, it is important to consider their joint effects when studying how the use of combined OCs may influence the brain and cognition, as combined OC users are realistically affected by both hormonal constituents in conjunction and not EE and progestins, separately. To simplify matters, all findings discussed henceforth will pertain to combined OCs containing EE and a progestin.

Similar to their endogenous counterparts, the hormones contained in OCs work on the HPG axis’ negative feedback loop by inhibiting the production of LH and FSH by the anterior pituitary and, in turn, preventing the release of estradiol and progesterone by the ovaries

(Bronson, 1981). Without LH, ovulation does not occur. Most combined OC formulations reduce endogenous estradiol and progesterone to levels equivalent (or inferior) to those in the early follicular phase of the menstrual cycle, when estradiol and progesterone are at their lowest (De Bondt et al., 2013; Mareckova et al., 2014; Rivera et al., 1999). Both the presence of exogenous hormones and the absence of endogenous hormones may contribute to brain and behavioural effects of OCs (Hampson, 2023). In the following section, I review basic OC pharmacology and mechanisms of action, as well as their potential effects on the brain and cognition.

1.2.1 Hormonal formulations

1.2.1.1 Ethinyl estradiol (EE)

Different types of OCs contain varying doses of EE, ranging from 10 to 35 micrograms per pill (Dickey & Seymour, 2021). Originally synthesized from estradiol, EE is structurally comparable to its endogenous counterpart at the molecular level, the only difference being that EE contains an additional ethinyl group which may enhance its potency and binding affinity to ER α in the CNS compared to endogenous estradiol (Stanford et al., 2004). Compared to estradiol, EE has twice the binding affinity for ER α , which may translate to greater neurotrophic and neuroprotective actions in the CNS (Jeyakumar et al., 2011). On the other hand, EE has slightly lower affinity for ER β compared to endogenous estradiol (Escande et al., 2006; Jeyakumar et al., 2011). It is possible that such differences in receptor affinities may lead to distinctions in the brain and/or behavioural outcomes of EE and endogenous estradiol, although supporting evidence is sparse and inconclusive (see Hampson, 2023).

1.2.1.2 Progestins

In addition to EE, combined OCs also contain one of several progestins. Although progestins act primarily through progesterone receptors, they vary markedly in their

pharmacological profiles and effects in the CNS (Dickey & Seymour, 2021; Mitchell & Welling, 2020; Schindler, 2015; Sitruk-Ware & Nath, 2010; for a systematic review, see Pletzer et al., 2023b). First and second generation progestins, typically derived from testosterone, have varying degrees of androgenic activity and share similar side-effect profiles (Batur et al., 2003; De Leo et al., 2016; Guerra et al., 2013). Many of these older generation progestins can exert either estrogenic or anti-estrogenic effects in the CNS via their binding to ERs (Dickey & Seymour, 2021; Sitruk-Ware, 2005). Third generation progestins, on the other hand, exert less androgenic actions (Kuhl, 1996). Fourth, or “new”, generation progestins bind to progesterone receptors and exert anti-androgenic effects, and many also lack binding affinity to ERs and in turn do not exert any kind of estrogenic effect in the CNS (Sitruk-Ware & Nath, 2010; Wiegratz & Kuhl, 2006).

1.2.1.3 Phasic regimen

The dosage of EE and/or progestin may vary across the pill cycle depending on the phasic regimen of OC. Most OC formulations consist of three weeks of active (i.e., hormone-containing) pills and one week of inactive (i.e., not hormone-containing) pills, during which a withdrawal bleed typically occurs, corresponding to menses. The inactive or placebo week is optional, meaning that users can choose to skip that week and begin their new pill packet immediately, essentially taking their active pills continuously. Monophasic OCs provide a constant dose of EE and progestin in each active pill for three weeks, followed by one week of inactive pills at the end of the cycle. Multiphasic OCs, on the other hand, deliver varying amounts of EE and/or progestin throughout the cycle to more closely mimic the hormonal fluctuations of the natural menstrual cycle. There are two types of multiphasic OCs: biphasic and triphasic. Biphasic pills maintain a consistent dose of EE, while progestin levels increase halfway through the three-week active pill cycle. Triphasic pills contain three separate doses of

EE and/or progestin, changing every seven days. Both types typically include one optional week of inactive pills. Importantly, even during this inactive pill week, levels of endogenous estradiol and progesterone resemble those in the early follicular phase (i.e., menses) phase of the natural menstrual cycle due to OCs' prolonged ability to inhibit their production (Petersen et al., 2014; Griksiene & Ruksenas, 2011).

1.2.1.4 Administration and timing

OC pills are ideally taken at the same time every day. After ingestion, OC hormones are absorbed into the bloodstream, typically reaching their peak serum concentrations within two hours and declining shortly afterward to levels resembling those in the menstrual phase of naturally cycling individuals (DiLiberti et al., 2011). It can take two to three pill cycles for serum concentrations of OC hormones to reach stable levels in individuals starting OC use for the first time. After this initial period, concentrations tend to remain consistent, with little variation observed between the third and subsequent cycles (e.g., Sanger et al., 2008; Zacur et al., 1992). Following pill discontinuation, former OC users occasionally show lower circulating levels of endogenous estradiol and progesterone, although these hormones usually return to their baseline levels in the long term (Chan et al., 2008).

Behavioural differences may emerge between the active and inactive phases of the pill cycle. For example, Hampson et al. (2022) observed that OC users performed differently on a mental rotation task depending on the pill phase during which they were tested. On the other hand, Mordecai et al. (2008) found no significant differences between OC users and non-users on a cognitive battery assessing verbal and visual memory, mental rotation, and attention; yet when OC users were compared by pill phase, those tested during the active pill phase performed better than those tested during the inactive phase.

Time of pill ingestion may also affect verbal memory: OC users who ingested their pill close to two hours prior to cognitive testing (when plasma estradiol levels are estimated to be at their highest) had better retention on a story recall task than those who took their pill afterward (Peragine et al., 2020). These findings contrast with those of Islam et al. (2008), who found no significant differences in verbal memory between OC users and non-users. Other studies have reported null findings in this cognitive domain (Gordon & Lee, 1993; Mihalik et al., 2009; Wharton et al., 2008); however, these studies used rather heterogeneous OC user groups with respect to pill phase and ingestion time.

The findings described above suggest that, analogous to findings on endogenous sex steroids, exogenous sex hormones can exert significant effects in the CNS through similar mechanisms. Such effects may be modulated by various OC-related factors such as hormonal formulation, pill phase, and time of pill ingestion, and may be associated with short- and long-term structural, functional, and behavioural outcomes. These are discussed in detail throughout the following sections.

1.2.2 Effects on brain structure and function

Recent systematic reviews have reported intriguing yet mixed findings regarding OC-related alterations in the structure and function of nearly all regions of the brain (Brønnick et al., 2020; Heller et al., 2022; Song et al., 2023). For the sake of conciseness, this section will mainly focus on findings relevant to regions most strongly implicated in episodic memory and executive control.

1.2.2.1 Structural imaging findings

Several studies have detected associations between OC hormones and regions of the temporal and frontal lobes, which may help explain potential effects in the corresponding

cognitive domains of episodic memory and executive control. A series of neuroimaging studies by Pletzer and colleagues reported changes in GMV across several pertinent brain areas, a subset of which was moderated by progestin androgenicity and the pill phase in which OC users were tested. First, Pletzer et al. (2010) observed reduced GMV in frontal and temporal lobe structures among OC users compared to naturally cycling females scanned during the early follicular (i.e., low hormone profile) and mid-luteal phases (i.e., elevated hormonal profile) of their menstrual cycles.

Pletzer et al. (2015a) subsequently identified effects of progestin androgenicity, with larger GMV in temporal structures (i.e., parahippocampal place area, fusiform face area) among anti-androgenic OC users, which were related to improved performance on a face recognition task compared to naturally cycling participants measured in the early follicular phase. Compared to non-users, androgenic OC users had smaller volumes in the PFC. Additionally, OC users in the inactive pill phase had larger temporal lobe structures than those in the active phase, pointing to the possibility of short-term, phasic changes in brain volume across the pill cycle.

Furthermore, duration of OC use was positively associated with volumes of the abovementioned areas as well as the hippocampus and total GMV, findings which were especially pronounced for those taking OCs with androgenic progestins (Pletzer et al., 2015a). Pooled analyses from previous publications suggested that OC users had smaller regional GMV than naturally cycling females in the right parahippocampal/fusiform gyrus. OC users also showed smaller GMV in the left hippocampus compared to naturally cycling females (Pletzer et al., 2019a).

Two quasi-experimental studies also reported significant relations of OC initiation with changes in GMV. First, Lisofsky et al. (2016) reported reduced left amygdala/anterior parahippocampal gyrus volumes after only three cycles of OC use compared to naturally cycling

controls. Notably, neither previous OC use nor progestin androgenicity or dosage contributed statistically to this effect (Lisofsky et al., 2016). Furthermore, a randomized crossover study showed that one cycle of OC use was associated with significantly lower PFC thickness than non-users (Petersen et al., 2021).

Taken together, the above findings suggest that OC use is linked to structural changes in regions responsible for episodic memory and executive control. However, this picture is not yet entirely clear due to mixed findings in the literature and an overall scarcity of neuroimaging studies employing behavioural measures.

1.2.2.2 Functional imaging studies

In addition to structural changes, functional changes related to OC use have been demonstrated predominantly in the PFC, both during the completion of cognitive tasks and at rest. To the best of our knowledge, no functional imaging studies have yet examined brain activity in relation to episodic memory tasks in OC users. In one study, OC users showed increased brain activity in regions of the frontal cortex during an emotional working memory task compared to naturally cycling females (Sharma et al., 2020b). This heightened activity was positively associated with OC use duration. Moreover, participants who began using OCs earlier, during puberty, showed greater regional white matter volumes and increased brain activity during the same working memory task compared to those who initiated OCs later, in adulthood.

Using resting state fMRI, Petersen et al. (2014) found reduced functional connectivity within the default mode network and executive control network in OC users compared to naturally cycling females. On a related note, Lisofsky et al. (2016) found reduced functional connectivity between the dorsolateral PFC and amygdala/anterior parahippocampal cortex in OC users after only three pill cycles. Taken together, these findings suggest that OCs, even if only

taken for a short amount of time, can significantly alter brain activity, possibly leading to changes in cognition.

1.2.3 Effects on cognition

Considering how long OCs have been available, there have been remarkably few published reports examining their role in cognition. Available studies have revealed preliminary patterns of the possible effects of OC use on discrete cognitive functions, including verbal and visual learning and recall, visuospatial ability, verbal fluency, and aspects of working memory (for systematic reviews, see Beltz, 2022; Gurvich et al., 2023; Warren et al., 2014; for a meta-analysis, see Kowalczyk et al., 2023). The following section will focus primarily on findings related to episodic memory and executive control.

1.2.3.1 Episodic memory

Despite mixed findings, systematic reviews suggest that OC use enhances verbal episodic memory overall (Gurvich et al., 2023; Warren et al., 2014). OC users tend to perform comparably to naturally cycling females during phases of high circulating endogenous ovarian hormones (Gogos, 2013; Peragine et al., 2020; Silber et al., 1987; but see Wharton et al., 2008). For example, OC users showed similar performance to non-users tested during the midluteal phase (i.e., high hormone profile) on immediate and delayed story recall (Gogos, 2013; Peragine et al., 2020) and word list recall (Gogos, 2013). In this last study, OC users also outperformed naturally cycling participants in the early follicular phase. Similarly, Hochheim et al. (2025) found no significant differences between OC users and naturally cycling participants on a word list recall task; however, OC users had marginally higher scores than non-users tested during the follicular phase (i.e., low hormone profile).

Periods of elevated *synthetic* hormone concentrations, such as during the active pill phase and shortly following pill ingestion, have been linked with improved verbal episodic memory. In one study, Mordecai et al. (2008) found no significant differences between OC users and non-users on a cognitive battery assessing verbal and visual memory, mental rotation, and attention. Yet, OC users who were tested during the active pill phase had better verbal learning on a word list recall task than users in the inactive pill phase. Moreover, OC users who ingested their pill close to two hours prior to cognitive testing (when plasma estradiol levels are estimated to be at their highest) had better retention between immediate and delayed recall on a story recall task than females in the early follicular phase (Peragine et al., 2020). It follows that the enhancing effect of OC use on episodic memory may be most prominent for delayed recall of verbal materials. In a more recent study, OC users showed slightly (but not significantly) higher verbal memory scores than male participants (Davignon et al., 2024), suggesting that OC use may enhance sex-related differences in verbal memory. Notably, this improvement in performance arose between the short and long delay recall trials of the task. The authors speculated that long-term memory processes employed for delayed recall, such as storage or retrieval, may therefore be more responsive to OC-related changes. Interestingly, Plamberger et al. (2021) observed enhanced performance overnight, from immediate (pre-sleep) to delayed (post-sleep) recall, in OC users compared to non-users in the follicular phase, pointing to a possible association between OC use and episodic memory consolidation.

Other studies have reported null effects of OC use on verbal memory, both between OC users and non-users (Islam et al., 2008; Kuhlmann & Wolf, 2005; Mihalik et al., 2009; Silber et al., 1987; Wharton et al., 2008) and across pill phases (Genzel et al., 2015; Gurvich et al., 2020; Islam et al., 2008; Mihalik et al., 2009). Additionally, there is a lack of evidence supporting any

effect of progestin type on verbal memory (Gogos, 2013; Gurvich et al., 2020; Wharton et al., 2008).

Compared to studies examining verbal memory, relatively few published reports have investigated the effects of OC use on memory for non-verbal materials. In one study, OC users were better at identifying new objects in an object array task than naturally cycling females (Thrasher et al., 2023). Gogos (2013), on the other hand, observed that OC users performed similarly to naturally cycling females in the high estradiol and progesterone phase of their cycle on an index score of visual and verbal memory. Similarly, Islam et al. (2008) found no significant differences between OC users and non-users on a delayed matching-to-sample task, pointing to the need for more dedicated research in non-verbal memory domains.

1.2.3.2 Executive control

Neuroimaging research has linked OC use to structural and functional changes in the PFC and other regions implicated in executive control (Gingnell et al., 2016; Kirschbaum et al., 1999; Petersen et al., 2014; Pletzer et al., 2010, 2014, 2015a, 2016; Sharma et al., 2020ab), suggesting possible associations with executive functioning. Although a recent meta-analysis reported no overall effect of OC use on executive control (Kowalczyk et al., 2023), prior systematic reviews have noted individual study findings supporting OC-related influences on specific executive subdomains such as working memory, inhibitory control, set shifting, and verbal fluency (Gurvich et al., 2023; Warren et al., 2014). Both OC users and naturally cycling females show improved spatial working memory during high estradiol states (Hampson, 2018a; Hampson & Morley, 2013; for a review, see Hampson, 2018b). In another study, no group differences were found on a complex working memory task, although OC users in the active pill phase made more errors than naturally cycling controls in the follicular phase, but not compared to those in the

luteal phase (Kowalczyk et al., 2023). Moreover, Gurvich et al. (2020) found that users of androgenic OCs outperformed anti-androgenic users on a set-shifting task.

Verbal fluency performance may also be moderated by progestin androgenicity: One study showed that users of androgenic progestins had lower verbal fluency scores than anti-androgenic OC users (Griksiene & Ruksenas, 2011). Duration of OC use has also been claimed to positively predict verbal fluency performance, such that individuals using OCs for over nine years had greater scores than naturally cycling participants (Davignon et al., 2024).

Despite the abovementioned findings, most studies assessing executive control, including our own (Jensen et al., 2023), have found little or no support for OC-related effects on measures of working memory, verbal fluency, or set-shifting (Becker et al., 2020; Gurvich et al., 2020; Herrera et al., 2020; Islam et al., 2008; Jensen et al., 2023; Kuhlmann & Wolf, 2005; Mordecai et al., 2008; Rosenberg & Park, 2002). Although most of the literature on executive control points toward there being no noteworthy effect of OC use, the significant findings from previous neuroimaging studies outlined above, coupled with evidence from animal research on ER expression in the PFC (e.g., Wang et al., 2010), tell us that this area of cognition is in need of further investigation.

1.2.3.3 Effects of OC use duration

Most OC users take OCs for several years (Liu et al., 2017), yet research exploring the link between OC use duration and cognition remains limited (Gurvich et al., 2020; for a review, see Warren et al., 2014). In general, findings from both prospective and retrospective reports support the existence of a relationship between OC use duration and various cognitive domains. Short-term changes in brain structure with OC initiation have previously been identified (Lisofsky et al., 2016), and longer duration of OC use has been linked to greater total GMV, as well as greater

hippocampal and frontal lobe volumes, especially among those using androgenic formulations (Pletzer et al., 2015a). Interestingly, duration of previous OC use was also positively related to hippocampal volume in individuals no longer using the pill; however, this effect disappeared after controlling for time since discontinuation (Pletzer et al., 2019a).

Other studies that retrospectively examined the relations between OC use and cognition reported that previous OC use was associated with better memory and executive control later in life (Egan & Gleason, 2012; Karim et al., 2016; Watts et al., 2025) and a reduced incidence of dementia (Gong et al., 2021; Yoo et al., 2020). Mixed findings have been uncovered for verbal fluency: In younger adult samples, longer duration of OC use has been linked to both reduced (Noachtar et al., 2022) and improved verbal fluency scores (Davignon et al., 2024; Hampson, 2025). However, in this last study, Hampson (2025) found no significant differences on verbal fluency between former OC users, current users, and never-users irrespective of duration of pill use. Moreover, we previously found no significant relations of OC use duration with our episodic memory or executive control measures among OC users aged 18-30 (Jensen et al., 2023).

Taken together, these findings hint toward OCs having both short-term and enduring consequences on brain structure and cognition, although these effects may depend on OC formulation and time since discontinuation in individuals no longer using OCs.

1.2.4 Interactions with mood

While the present thesis primarily examines the cognitive effects of OC use, it also considers the potential confounding effects of OC use on mood, as emotional factors may influence cognitive functioning (Goodall et al., 2018). Findings on the mood-related effects of OC use have been mixed (for reviews, see Hampson, 2023; Kraft et al., 2024). Some studies suggest that OC use may be associated with depressive symptoms (Johansson et al., 2023;

Masama et al., 2022; Zettermark et al., 2018), especially among individuals with a history of depression (Bengtsson et al., 2018; Lundin et al., 2017) or previous negative mood linked to OC use (Gingnell et al., 2013). Other studies have found no significant associations (Duke et al., 2007; Garforth et al., 2020; Griksiene et al., 2018; Griksiene & Ruksenas, 2011; Lundin et al., 2022; McKetta & Keyes, 2019; Mordecai et al., 2017), including our own (Jensen et al., 2023), and some have even reported improved mood with OC use (Toffol et al., 2011, 2012; Keyes et al., 2013). In some cases, the extent of associations observed between mood and OC use may depend on OC formulation (Rapkin et al., 2019; Schaffir et al., 2016; Shahnazi et al., 2014), age at initiation (Skovlund et al., 2016; Anderl et al., 2022), and the methods used to assess mood (Hampson, 2024). For example, one study found that second generation OC users displayed a decrease in positive affect and an increase in negative affect post-treatment; conversely, third generation OC users showed the opposite pattern (Shahnazi et al., 2014).

Potential neural and biological mechanisms may underlie these emotional effects. OC use has been associated with structural and functional changes in brain regions and networks involved in emotional processing (Brønnick et al., 2020; Heller et al., 2022; Toffoletto et al., 2014), including the amygdala, anterior cingulate cortex, and fornix (De Bondt et al., 2013; Gingnell et al., 2013; Menting-Henry et al., 2022; Petersen et al., 2014; Petersen & Cahill, 2015). Additionally, OC users may show reduced hypothalamic-pituitary-adrenal (HPA) axis reactivity and cortisol responses (Kirschbaum et al., 1999; Roche et al., 2013; Sharma et al., 2020b), potentially increasing their susceptibility to negative mood and mood disorders. It remains unclear, however, whether these effects result from the presence of synthetic hormones or the low availability of endogenous sex steroids (Heller et al., 2022).

1.2.5 Overview of Jensen et al. (2023): Cross-sectional study of OC-related effects on cognition

With the goal of addressing the many limitations in the literature to better inform our understanding of OC effects on cognition, we recently looked at the degree to which biological sex and OC use might affect individual episodic memory, executive control, and mental rotation in a large sample of healthy, young adults ($N = 155$, including 52 OC users, 53 naturally cycling females, and 50 males) tested individually over videoconference (Jensen et al., 2023). To measure cognition, we used a set of neuropsychological tasks inspired by Glisky and colleagues' two-factor episodic memory and executive control battery, from which two composite scores (based on principal component analysis) were derived for each participant.

Our pre-registered analysis revealed a clear female advantage on the episodic memory composite. In terms of individual memory tests, OC users significantly outperformed males and had slightly higher scores than naturally cycling females on delayed story recall, although this difference was not statistically significant. In an exploratory analysis, gist memory was elevated in OC users compared to male controls. There were no significant sex-related differences or effects of OC use on our other cognitive measures of executive control or visuospatial ability. No significant relations between OC use and mood or between duration of OC use and cognition were observed. These results suggested that, in this sample of healthy, young adults, the use of combined OCs may be associated with slight improvements in episodic memory. However, this study was limited by its cross-sectional design, lack of control over certain OC-related variables (e.g., formulation) and menstrual cycle phase of control participants, and minimal information about participants' history of HC use. As discussed in the following section, these limitations are common across the OC literature, and I plan to address many of them in the present thesis.

1.2.6 Limitations of previous studies

Thanks to a growing literature, we are beginning to understand the role of OC use in the brain and cognition; however, as outlined above, findings thus far have been relatively mixed and often contradictory due in part to the numerous methodological limitations of previous studies, including the inadequate consideration of variables that may moderate OC-related outcomes and nonexperimental research designs. Although many limitations have been identified and discussed in previous reviews (e.g., Beltz, 2022; Gurvich et al., 2023; Hampson, 2023; Laird et al., 2019; Taylor et al., 2021; Warren et al., 2014), I will focus on those most relevant to the present thesis.

The first set of limitations pertains to the inadequate consideration of OC-related and individual-level factors. The default approach used by many previous studies has been to cluster all OC users together into a homogeneous group and compare them to non-users, overlooking many characteristics associated with OC use and the menstrual cycle that may contribute to variations in cognitive outcomes, such as pill types and history of use. For example, the “non-users” group often includes both individuals who have never used OCs and those who have used them in the past but are now naturally cycling, an important distinction since some OC effects may persist after discontinuation (Chan et al., 2008). Additionally, most research thus far has failed to account for differences across OC subtypes. As reviewed above, OC pills vary in hormone dosage, hormonal formulation, and phasic regimen, all of which may influence outcomes (Hampson, 2023). Considering such factors will allow researchers to attribute specific findings to particular kinds of OCs.

Other individual-level variables that may modulate the effects of OCs on cognition, including temporal factors (e.g., duration of current OC use, age at OC initiation) and hormonal

characteristics of control participants (e.g., menstrual cycle phase) have been vastly overlooked in previous studies despite research showing their significant contributions to OC effects on the brain and cognition (Laird et al., 2019; Taylor et al., 2021). It is therefore important that studies consider these factors in the study conceptualization stage, as opposed to including them in their analyses *post hoc* (Beltz, 2022), to gain a more comprehensive understanding of the complex effects of OC use in the CNS.

The second set of limitations concerns study methodology and statistical design. Many earlier studies (published between 1975 and 2013) relied on relatively small participant samples, with an average N of 24 (Warren et al., 2014), which likely limited their ability to detect subtle effects of OC use. However, studies with small samples can be justified if they employ predetermined power analyses, hypotheses, and analyses, although few OC studies to date have been pre-registered. While more recent research has begun to use larger samples to differentiate between OC types, most still employ cross-sectional designs, including our own initial one (Jensen et al., 2023). Cross-sectional studies are not only limited in their ability to make causal inferences between variables but may be especially vulnerable to individual differences in cognition, as measures are taken at a single point in time and performance may therefore be influenced by a range of individual-level, social, and biological factors.

Employing more rigorous, experimental designs may be more appropriate for OC research. Robust study designs that account for both between- and within-subjects differences are still rare in this field but are essential for understanding how OC use may affect cognition. While a few quasi-experimental designs and randomized controlled trials (RCT) have been published (e.g., Lisofsky et al., 2016; Gingnell et al., 2013), they are few and far between. Although they are more challenging to undertake, studies with such designs present many

advantages over cross-sectional ones by allowing greater control over variables, stronger causal inferences, and more reliable conclusions about one's findings. Given the inherent complexity of OC effects on the brain and behaviour, such methods are preferred (further discussed in [Section 1.3.1](#)).

1.3 Methodological challenges addressed in this thesis

My previous research (Jensen et al., 2023) addressed many limitations from the literature at that time but still left some important questions unanswered. In the present thesis, I aimed to address these outstanding limitations by implementing a quasi-experimental methodology and updating our laboratory's neuropsychological battery for remote use to reach a larger sample of OC users. I also included a measure of self-reported memory to examine the possible effects of OC initiation on subjective recollection of everyday experiences. Below, I explain how the present thesis will tackle these methodological challenges.

1.3.1 Quasi-experimental study design

One of the most significant limitations in the OC literature that I was unable to address in my previous research (Jensen et al., 2023) is the paucity of experimental studies. Experimental and quasi-experimental designs are crucial as they enable researchers to more rigorously examine the effects attributable to OCs while controlling for potential confounding variables. While RCTs are considered the gold standard in the field, a more practical and feasible option—particularly in the context of thesis research, where financial and ethical constraints are more prominent—is the use of a prospective, quasi-experimental design to examine the effects of OC initiation on cognitive outcomes.

Lisofsky et al. (2016) used such a design to compare $n = 28$ newly initiated OC users with $n = 28$ naturally cycling females tested during the follicular phase on measures of cognition,

GMV, and functional brain activity. OC users were self-selected (i.e., were already planning on starting OCs when they were recruited for the study) and were tested once before beginning OCs and again after three treatment cycles. The authors found no significant effects of OC initiation on any aspects of cognition, including verbal episodic memory (i.e., word-list recall, face-name cued recall) and executive control. Yet, compared to naturally cycling controls, OC users showed decreased GMV in the left amygdala and anterior parahippocampal gyrus. Additionally, the resting state functional connectivity between these regions and the PFC changed significantly, from positive to negative, following three months of OC use. These findings hint toward potential effects of short-term OC use on the neural underpinnings of mood and emotional regulation; however, the lack of behavioural findings suggest that potential cognitive effects may be smaller than neural changes attributable to OCs, be observable only on certain cognitive tasks, or vary considerably between individual OC users.

Although this study was methodologically superior to most studies in the literature to date thanks to its quasi-experimental design, it was limited in several ways. First, the authors did not perform an a priori power analysis for their cognitive analyses (or at least, they did not report it), so it is possible that this study was not sufficiently powered to detect a small group-by-time interaction effect. Second, they used ten individual cognitive tasks and performed multiple analyses, forcing them to correct their *p*-values, which may have masked potential small OC effects.

The present thesis—particularly Study 3—is inspired by Lisofsky et al. (2016) and aims to expand on their findings while making some methodological refinements. First, I employed a larger sample of “new” OC users to have greater statistical power to detect subtle cognitive effects of OC initiation over time (Beltz, 2022). Second, I formed a second control group of OC

users who had been using the pill for at least 6 months to allow for the detection of potential effects related to OC initiation and short-term use in “new” users that may differ from effects of longer-term use. Third, I ensured that all OC users were tested during the inactive pill phase and that naturally cycling participants were tested during menses, to control for potential phase effects. Finally, I used composite neuropsychological scores to measure episodic memory and executive control.

1.3.2 Neuropsychological composites

Using composite neuropsychological scores offers several advantages over single cognitive tests: They provide more stable estimates of cognitive domains, reduce the number of statistical comparisons, and minimize measurement error, thereby increasing statistical power to detect subtle cognitive effects of OCs (Davidson & Jensen, 2022; Jensen et al., 2025).

The composite neuropsychological scores used in the present thesis are inspired by Glisky and colleagues’ two-factor episodic memory and executive control composites (Glisky & Kong, 2008; Glisky et al., 1995, 2001). These have been replicated in both older and young adults and are still widely used today (Daley et al., 2024; Davidson & Jensen, 2022; Jensen et al., 2023; West et al., 2025). Although most component tests avoid ceiling effects and are suitable for use with healthy young adults, the composites have been shown to yield similar but not identical factor structures in young and older adults (Chan & McDermott, 2007; Glisky & Kong, 2008; McCabe et al., 2010), suggesting that they may measure slightly different constructs in different age groups. Additionally, older adults sometimes report familiarity with the individual tests, such as Wechsler’s Logical Memory, likely due to prior exposure to these tasks, which may threaten validity.

To address these issues, I have updated Glisky et al.'s battery by selecting a new set of valid and less commonly used memory measures from the experimental literature that are better suited to young adults and remote administration, thus reducing overlap with clinical tests and increasing our composite scores' relevance for the current thesis (see [Section 2.9](#)).

1.3.3 Remote neuropsychological testing

Because of changes to testing protocols in light of the COVID-19 pandemic, and to reach a greater number of participants, the neuropsychological battery used in the present thesis was administered remotely. Remote testing usually requires minimal modifications of the traditional lab-based tasks and still allows researchers to supervise participants and provide additional feedback or instructions when necessary (Belleville et al., 2023). In general, studies have found support for the reliability and validity of the remote or computerized administrations of widely used neuropsychological batteries (Backx et al., 2020; Brown & Zakzanis, 2023; Germine et al., 2012; Kochan et al., 2022; Rebchuk et al., 2019; Uittenhove et al., 2023; for a review, see Belleville et al., 2023). Previous studies have also employed remote versions of the tasks used in the present thesis, and nearly half of these have been validated for remote use or directly compared to their in-person equivalents (Brearly et al., 2017; Brown et al., 2018; Cyr et al., 2021; Mahon et al., 2022).

Many of these tasks have been administered to young adults via videoconference in our previous study (Jensen et al., 2023). To assess the reliability and suitability of their web-based, remote versions, and to ensure that these yield similar results to their videoconference-based versions, I have piloted the neuropsychological battery with young adults using both testing modalities (see [Section 2.9](#)).

1.3.4 Considering subjective memory

Objective, laboratory-based neuropsychological tests of episodic memory are intended to estimate individuals' memory functioning; however, they may be limited in their ecological validity and generalizability to everyday memory abilities and to cognitive domains other than those which they are intended to measure (Chaytor & Schmitter-Edgecombe, 2003; Isquith et al., 2013). Consequently, objective cognitive tests may fail to capture some of the subtle changes or disturbances in memory that people perceive in their everyday environment (Bell et al., 2020; Isquith et al., 2013). A valid and useful supplement to measuring objective memory is the assessment of subjective memory through self-report questionnaires (Bell et al., 2020), which provide information about individual perceptions and uses of memory in real-world settings that cannot always be tapped using objective neuropsychological tests. In this dissertation, I measure subjective memory using the Multifactorial Memory Questionnaire (MMQ; Troyer & Rich, 2002), which shows good validity and reliability for use in non-clinical samples (Troyer et al., 2019).

Ovarian steroid hormones, especially estradiol, may be associated with people's perceptions about their memory. Most studies on this topic have focused on subjective memory complaints in middle-aged individuals during the menopause transition (Reuben et al., 2021; Schaafsma et al., 2010; Weber et al., 2012). In general, peri- and postmenopausal women tend to report more subjective memory complaints than premenopausal women, and more frequent subjective memory concerns during this period may be linked to lower levels of circulating ovarian hormone (for a review, see Reuben et al., 2021). For example, in one study using the MMQ, perimenopausal women were less satisfied with their memory and reported more memory mistakes than both pre- and postmenopausal women, yet groups did not differ on objective memory (Unkenstein et al., 2016). Additional evidence for potential associations with sex

hormones stems from research on sex differences in subjective memory (Csábi et al., 2023; Derouesné et al., 1999; Parisi et al., 2011; Raimo et al., 2016; Tomita et al., 2014; Van der Elst et al., 2011; Van der Werf & Vos, 2011; for a review, see Jonker et al., 2000). On the MMQ specifically, women have reported lower memory satisfaction, more frequent memory mistakes, and greater use of strategies than men (Csábi et al., 2023; Van der Werf & Vos, 2011).

Few reports have examined the relationship between subjective memory and sex hormones in young, premenopausal females, and none (to the best of my knowledge) have examined associations with hormonal contraception. One exception is an unpublished Master's thesis which examined the effects of menstrual cycle phase on metacognitive judgments of accuracy (Whitfield, 2005). In each phase of their menstrual cycle, participants completed a series of objective cognitive tests and rated their perceived efficacy on each task before and after completion. No significant differences in metacognitive judgement accuracy (i.e., difference between subjective ratings and objective performance) were found across different menstrual cycle phases. This research question was motivated by the findings of earlier studies looking at the relationship between objective cognitive test performance and premenstrual cognitive symptoms (i.e., problems with concentration, memory, processing speed) that are commonly reported during the luteal phase of the menstrual cycle. No significant differences in objective test performance were detected between those who experienced such symptoms and those who did not (e.g., Morgan et al., 1996; Morgan & Rapkin, 2002; Resnick et al., 1998).

Although studies examining the effects of ovarian steroid hormones on subjective cognition in young adults are scarce, the findings outlined above suggest that subjective perceptions of one's memory may be influenced to some extent by one's hormonal milieu. I intend to further explore this relationship in the present thesis.

1.4 Thesis objectives

This dissertation builds on the findings of Jensen et al. (2023) and aims to address many of the outstanding methodological limitations in the OC-cognition literature. It does so by directly examining the effects of OC use on episodic memory using a prospective, quasi-experimental design, and also explores the possible relations of OC use with subjective memory, a new avenue of research in this field.

Throughout the following chapters, I present four successive stages of my research which all act as building blocks toward answering the question central to this thesis. Chapter II focuses on establishing the methods that will be used in Chapter III. In Chapter II, I examine the suitability of the MMQ for assessing self-reported memory in healthy young adults to inform the use of this scale in future research ([Study 1](#)). Also in Chapter II, I pilot our laboratory's updated neuropsychological composite battery for remote use with young adults and assess the reliability of parallel versions of the episodic memory measures for repeated testing ([Study 2](#)). In Chapter III, Part 1, I employ a within-subjects, pre-post study methodology to examine the effects of OC use initiation on objective and subjective memory. In Chapter III, Part 2, I replicate our previous study on OC use and cognition (Jensen et al., 2023), using our updated neuropsychological battery and applying more restrictive parameters with respect to pill phase, type of OC, and duration of use ([Study 3](#)). Notably, this final study incorporates the novel contributions of preceding chapters, by employing our newly developed composite neuropsychological battery for remote use and assessing subjective memory in OC users for the very first time.

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2. CHAPTER II – Assessing the suitability of a subjective memory questionnaire and remote neuropsychological battery in young adults

The following chapter presents two studies that were conducted to establish and validate the methods used in Study 3, while addressing the methodological challenges outlined in [Section 1.3](#). Specifically, these studies focus on the assessment of subjective memory in young adults ([Section 1.3.4](#)) and the development of a remotely administered neuropsychological battery suitable for repeated assessment of episodic memory ([Sections 1.3.1 to 1.3.3](#)).

Study 1 (Jensen et al., 2024), which was published in *Memory*, examined the suitability of the MMQ for use in healthy young adults. Although the MMQ is a widely used measure of subjective memory, it was originally developed for older adults, and its psychometric properties had not yet been thoroughly examined in younger populations. Confirmatory factor analysis and measurement invariance testing revealed that the original factor structure was replicated in older adults and age invariance was not supported. These findings suggest that the MMQ may not measure identical constructs across age groups and that caution is warranted when comparing young and older adults on this questionnaire. Because we did not find support for age invariance, we had intended to amend the MMQ to render it more suitable for young adults (for example, by removing items geared toward older individuals); however, because the MMQ is the property of its authors, we did not make any modifications to the scale. Considering that previous studies have used the MMQ with young adult samples, providing us with a useful basis for comparison, we decided to retain the original MMQ in Study 3.

Study 2 was a pilot study designed to prepare our neuropsychological battery for remote administration and repeated testing in Study 3. To this end, we developed parallel versions of the episodic memory tasks, converted the battery for self-administered web-based testing, and

examined its factor structure. Results indicated that performance on the web-based version was comparable to the original videoconference-based version, thus supporting the suitability of the battery for remote use. Factor analysis further supported the two-factor structure of the episodic memory and executive control battery, although the 4MT showed weaker associations with the verbal episodic memory measures and was therefore excluded from the episodic memory composite used in Study 3. Finally, scores on the parallel forms were similar, although Version 1 of Story Recall and Verbal Paired Associates produced slightly higher scores than Version 2. To minimize the potential effect of these differences, we counterbalanced study versions across participants and standardized episodic memory scores across time points in Study 3.

Study 1 – Multifactorial Memory Questionnaire: A comparison of young and older adults

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Abstract

The Multifactorial Memory Questionnaire (MMQ; Troyer & Rich, 2002) is a widely used measure of subjective memory consisting of three scales: Satisfaction, Ability, and Strategies. Although subjective memory complaints are prevalent across different age groups, the factor structure and psychometric properties of the MMQ have yet to be examined in young adults. Here, we independently replicated the original MMQ factor structure in $N = 408$ young adults (YA) recruited from undergraduate courses and $N = 327$ older adults (OA) and, for the first time, assessed the age-invariance of the scale using measurement invariance testing. YAs made significantly higher ratings than OAs on MMQ-Satisfaction and MMQ-Strategies, indicating greater satisfaction with their memory and greater use of strategies, but the groups were similar on MMQ-Ability. The original MMQ factor structure was replicated in OAs but not in YAs, and age invariance was not supported. Future studies seeking to compare young and older adults could therefore consider either requesting modification of the MMQ for use with young adults or using a different scale.

Keywords: Subjective memory; aging; young adults; confirmatory factor analysis; age invariance

2.1 Introduction

Subjective memory assessment questionnaires are commonly used for clinical and empirical assessments of people's perceived strengths and weaknesses in their everyday memory. Because they can provide useful insights into dimensions of memory that may not be fully captured by objective memory tests (Gopi & Madan, 2023; Troyer & Rich, 2002; for a meta-analysis, see Crumley et al., 2014) and predict quality of life and real-world functioning (Shaikh et al., 2021b; for a review, see Mol et al., 2007), subjective memory assessments serve as a valuable complement to objective tests.

A reliable and widely used measure of subjective memory is the Multifactorial Memory Questionnaire (MMQ; Troyer & Rich, 2002). The MMQ is composed of three separate scales – Satisfaction, Ability, and Strategies – totalling 57 questions, and takes approximately 10 minutes for cognitively normal adults to complete. It was initially validated in a relatively large sample of cognitively healthy middle-aged and older adults. Since then, the scale has been used in dozens of published research articles and been translated into several languages. Troyer et al. (2019) assembled these findings in a meta-analysis and affirmed that the scale has remained a valid, reliable, and responsive measure for older populations (see also Csábi et al., 2023; Yang et al., 2023).

Memory complaints are prevalent among cognitively normal middle-aged and older adults (for reviews, see Gautier et al., 2022; Hertzog & Curley, 2018; Hertzog & Pearman, 2013), yet young adults also have complaints about their memory (Csábi et al., 2023; Raimo et al., 2016; van der Werf & Vos, 2011). Unfortunately, most of the scales that are currently used to assess self-reported memory in different age groups were developed specifically for aging populations (Gopi & Madan, 2023; Hertzog & Curley, 2018). This includes the MMQ (Troyer &

Rich, 2002), which has also been used numerous times with young adults (Csábi et al., 2023; Ling et al., 2020; Raimo et al., 2016; Ryan & Campbell, 2024; Singer et al., 2005; van der Werf & Vos, 2011; for a meta-analysis including adults of all ages, see Troyer et al., 2019). Given that individuals of all ages can make memory complaints and use memory strategies to at least some degree, it is important to ensure that our measures are sensitive to and appropriate for each examinee's age.

2.1.1 MMQ relations with age

In their original validation of the MMQ, Troyer and Rich (2002) did not find significant associations between participants' age and MMQ scales, but this may have been due to their age range being limited to 39–91 years old. Subsequent studies with older and/or adult-age-range samples ranging from 20 to 90 years old, on average, have reported small but significant negative age relations with MMQ-Satisfaction (Raimo et al., 2016; van der Werf & Vos, 2011; but see Csábi et al., 2023; Illman et al., 2015) and conflicting age relations with MMQ-Ability and MMQ-Strategies (Csábi et al., 2023; Guardia et al., 2024; Illman et al., 2015; Raimo et al., 2016; van der Werf & Vos, 2011). Young and older adults might interpret questions differently on the MMQ, making it important to verify that the scales reflect similar psychometric properties across age groups. Consistent with this idea, Karr (2022) recently examined the factor structure of MMQ-Strategies in young adults. The scale's factor structure showed acceptable but not excellent model fit (for a one-factor solution). To the best of our knowledge, no studies have yet examined the factor structure of *all three* MMQ scales for age-invariance to decide how the MMQ might be used in young adults.

2.1.2 MMQ relations with mood

In addition to participants' age, negative affective traits such as depressive symptoms may also be strongly related to subjective memory ratings (Chin et al., 2014; Csábi et al., 2023; Fort et al., 2004; Ku et al., 2023; Loprinzi, 2019; Mendes et al., 2008; Mogle et al., 2020; Mol et al., 2008; Montenegro Peña et al., 2013; Peavy et al., 2013; but see Pearman, 2009). While many of these studies used memory self-assessments other than the MMQ, their findings may still be generalizable because the MMQ is related to several other subjective memory questionnaires (Rabin et al., 2023). One study using the MMQ in a sample of young and older adults (range = 18–92 years) found that individuals with fewer depressive symptoms were more satisfied with their memory, reported better memory ability, and used memory aids and strategies less frequently than those with higher self-reported depression symptoms (Csábi et al., 2023). These associations remained even after controlling for age. Given the possible relations between mood and subjective memory ratings, in this study we sought to learn whether self-reported mood might be related to MMQ scores in the subset of our sample for which depression scores were available (i.e., $N = 155$ young adults and $N = 208$ older adults).

2.1.3 The present study

The MMQ has consistently been shown to be a valid and reliable measure of subjective memory in middle-aged and older adults, and several studies have also used the scale in young adults (e.g., Csábi et al., 2023; Raimo et al., 2016; van der Werf & Vos, 2011). Yet, the factor structure of all three MMQ scales has not yet been verified in younger populations; it is therefore unknown whether the factor structure of the MMQ is invariant across different age groups. In fact, several studies have suggested that a 4-factor structure (in which the Strategies factor is broken down into External versus Internal memory strategies) may provide a better fit than the

original 3-factor one in middle-aged and older adults (Csábi et al., 2023; Fort et al., 2004; Raimo et al., 2016; Shaikh et al., 2021a). Might this be the case with young adults, too?

The goals of the present study were thus to (1) replicate the original MMQ factor structure in young and older adults, (2) compare individual responses on each MMQ item between age groups, (3) compare the 3-factor and 4-factor structures of the MMQ between young and older adults using measurement invariance, and (4) explore the associations between mood/depression scores and MMQ scales in young and older adults, separately. To this end, we compiled several hundred archival MMQ responses from young and older participants in our lab over the last 15 years and, on the advice of a reviewer, collected additional data from young adults.

2.2 Methods

2.2.1 *Participants*

Participant data came from four separate archival datasets collected in our lab over the last 15 years (studies published as: Rabipour et al., 2020; Stamenova et al., 2014; Young-Bernier et al., 2015; theses published as: Bégin-Galarneau, 2019; Drouin, 2017; Rabipour, 2018; Young-Bernier, 2015). On the advice of a reviewer, we also collected data from an additional 230 university students in early 2024. All studies were approved by the University of Ottawa Research Ethics Board (#H-01-23-8977 and #H-01-24-9987) and participants provided informed consent prior to taking part in the individual studies. Our final sample consisted of 327 older adults (M age = 69.38, range = 53–91) and 408 young adults (M age = 19.60, range = 18–34). All participants reported being in good general and cognitive health at the time of testing and having normal or corrected-to-normal vision. Older adults were recruited from the Ottawa community through advertising, flyers, and word-of-mouth and were compensated according to the ethical

guidelines at the University of Ottawa. Young adults were recruited from the undergraduate research participant pool at the University of Ottawa and received partial course credit for their participation (a small number came from the community and were remunerated a small amount of money). The young adults from our archival dataset ($N = 178$) completed the study in-person, whereas those recruited in 2024 ($N = 230$) were administered the MMQ online via Qualtrics (because in-person recruiting was progressing slowly). Comparisons between the two young adult groups on demographic variables and MMQ responses are reported in Appendix A1.

Table 2.1. Participant demographics

	Young adults ($N = 408$)	Older adults ($N = 327$)
	<i>M (SD) or N</i>	
Sex		
Female	272	220
Male	132	104
Not specified	4	3
Age (years)	19.6 (2.24)	69.4 (5.82)
Education (years)*	13.4 (1.63)	16.6 (2.81)
MoCA	N/A	26.9 (2.55)
MoCA memory subscale	N/A	3.3 (1.69)
CES-D*	12.4 (8.83)	7.9 (6.91)

Note. CES-D = Center for Epidemiological Studies Depression Scale; MoCA = Montreal Cognitive Assessment. 208 older adults and 144 young adults completed the CES-D. 249 older adults completed the MoCA. * $p < .001$

Participant demographics, including the number of missing datapoints for each demographic variable, are presented in Table 2.1 (note that there were no missing datapoints for the MMQ specifically). Independent samples t -tests revealed that the older adults had completed significantly more years of education ($M = 16.60$, range = 6–27) than the young adults ($M = 13.40$, range = 11–22), $t(709) = 17.80$, $p < .001$, $d = 1.37$. However, we did not control for years of education in our analyses because most of the young adults would have achieved the same

level of education as the older adults once they would have graduated from their undergraduate programs (16 years). Of the 327 older adults, 249 completed the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). Participants achieved an average score of 26.90 out of 30 ($SD = 2.55$). Although it was initially recommended to exclude participants with MoCA scores lower than 26 (Nasreddine et al., 2005), this cutoff score may be too stringent and has been recommended to be as low as 20 (Carson et al., 2018; Malek-Ahmadi et al., 2015; Waldron-Perrine & Axelrod, 2012). Given the disagreement in the literature, and the fact that all our older participants were living independently in the community, we did not exclude participants based on their MoCA scores alone.

2.2.2 Materials

2.2.2.1 Multifactorial Memory Questionnaire (MMQ)

The MMQ comprises three separate scales assessing one's subjective memory experiences over the previous 2 weeks (Troyer & Rich, 2002; see Appendix A2). For each scale, items are rated on a 5-point Likert-type scale ranging from 0 to 4. MMQ-Satisfaction consists of 18 statements concerning one's general feelings toward their memory, including 11 negatively worded items (e.g., "My memory is really going downhill lately") and 7 positively worded items (e.g., "My memory is good for my age"). Participants are asked to rate how strongly they agree with each statement (0 = *Strongly disagree* to 4 = *Strongly agree*). Negatively worded items are reverse scored. MMQ-Satisfaction scores range from 0 to 72, with higher scores representing greater satisfaction with one's memory.

MMQ-Ability comprises 20 items describing common, everyday memory mistakes (e.g., "Not recall the name of someone you just met"). Participants are asked to rate the frequency at which they have experienced these mistakes over the last two weeks (4 = *Never* to 0 = *All the*

time). MMQ-Ability scores range from 0 to 80, with higher scores representing better memory ability and fewer memory mistakes.

MMQ-Strategies consists of 19 questions inquiring about the mnemonic strategies one uses in day-to-day life, including 11 internal strategies (e.g., “Mentally elaborate on something you want to remember”) and 8 external strategies (e.g., “Write things in a calendar, such as appointments or things you need to do”). Participants must indicate the frequency at which they used each strategy in the past two weeks (0 = *Never* to 4 = *All the time*). Total MMQ-Strategies scores range from 0 to 76, with higher values indicating more frequent use of memory strategies. This scale can be further divided into MMQ-Internal Strategies (items 3, 4, 6, 7, 8, 11, 13, 14, 16, 17, 19) and MMQ-External Strategies (items 1, 2, 5, 9, 10, 12, 15, 18) by summing the respective items belonging to each subscale (Shaikh et al., 2021a).

2.2.2.2 Center for Epidemiological Studies Depression Scale (CES-D)

A subset of our sample, including 209 older adults and 145 young adults, completed the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), a brief questionnaire assessing symptoms of depression in the general population. This scale consists of 20 items describing events that the participant may have experienced (e.g., “I had trouble keeping my mind on what I was doing”). For each item, participants are asked to indicate on a 4-point Likert-type scale (1 = *Rarely or none of the time* to 4 = *All of the time*) how often they experience each of these events in the previous week. Total scores are calculated by summing all 20 items and range from 0 to 60, with scores greater than 16 indicating possible depression. However, to remain as inclusive as possible, we did not exclude based on CES-D scores in our sample. Independent samples *t*-tests revealed that the older adults had significantly lower CES-D scores ($M = 7.96$) than the young adults ($M = 12.69$), $t(351) = 5.53$, $p < .001$, $d = .60$ (see Table 2.1).

2.2.3 Data analysis

Before running our analyses, we first assessed the normality of individual MMQ items in the full sample by checking the histograms, means, standard deviations, and skewness and kurtosis values. Most MMQ items were normally distributed (or close to it); however, some items were skewed or bimodal. Next, we compared groups on MMQ scale scores and individual MMQ items using independent samples *t*-tests. Welch's correction was applied to items that were not normally distributed and failed Levene's test for equality of variance. We used a significance threshold of $p < .05$ for the *t*-tests and corrected for multiple comparisons using the Holm-Bonferroni method. This first set of analyses was conducted using jamovi Version 2.3.21.0 (The jamovi project, 2021).

The analyses described below were performed in RStudio (version 2023.3.0.386; Posit Team, 2023). First, we used *equaltestMI* (version 0.6.0; Jiang et al., 2017) to conduct multiple-group confirmatory factor analysis (CFA) and measurement invariance to assess the age-invariance of the 3- and 4-factor MMQ structures. This was done by first testing the baseline models for young adults and older adults separately. Factor loadings above .30 were retained (Brown, 2006). The following absolute fit indices were used to indicate adequate model fit: root mean square error of approximation (RMSEA) $< .10$ (.01 = excellent fit, .05 = good fit, .08 = mediocre fit), standardized root mean square residual (SRMR) $< .08$, and non-significant χ^2 test (although we did not rely strongly on this test as it has been shown to almost always be significant with large samples; Harrington, 2008). We also used the comparative fit index (CFI) and the Tucker-Lewis index (TLI) to assess model fit relative to a more restricted/perfect model. Acceptable model fit was determined by CFI and TLI values $> .95$ (Brown, 2006). Second, we tested the configural invariance of our models to learn whether they had the same factor

structure. If we found support for configural invariance, as would be indicated by our chosen absolute and comparative fit indices falling within the thresholds specified above, we would then proceed to assess metric (i.e., same factor loadings), scalar (i.e., same item thresholds), and residual (i.e., same item residuals) invariance (Putnick & Bornstein, 2016). Next, we calculated the differences between the various model fit indices, i.e., Δ CFI, Δ RMSEA, Δ SRMR, for each of the following models: (1) configural and metric, (2) scalar and metric, (3) residual and scalar. Difference values Δ CFI < .01, Δ TLI < .01, Δ RMSEA < .015, and Δ SRMR < .03 were used to indicate model invariance (Chen, 2007).

2.3 Results

2.3.1 *Independent samples t-tests*

Independent samples *t*-tests were used to compare MMQ scale scores between groups. In contrast with older adults, young adults had significantly higher scores on MMQ-Satisfaction, $t(733) = 2.54, p = .011, d = .19$, and MMQ-Strategies, $t(733) = 3.15, p = .002, d = .23$, but not MMQ-Ability, $t(733) = .72, p = .475, d = .05$. The group difference on MMQ-Strategies was driven mainly by young adults' significantly greater use of internal strategies compared to older adults, $t(733) = 6.69, p < .001, d = .49$; however, older adults reported using significantly more external strategies than young adults, $t(733) = 2.77, p = .006, d = .20$. Here, we based our choice of internal and external strategies items on Shaikh et al.'s (2021a) 4-factor MMQ structure.

Next, we conducted 57 independent samples *t*-tests to compare age groups on each individual MMQ item. After applying the Holm-Bonferroni correction, significant age group differences were found on 37 MMQ items, including on 13 items belonging to MMQ-Satisfaction (#1, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 18), 9 items belonging to MMQ-Ability

(#4, 6, 10, 11, 12, 13, 14, 16, and 17), and 15 items belonging to MMQ-Strategies (#1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 15, 16, and 17). All *t*-test results are reported in Appendix A1.

2.3.2 Multiple-group CFA and measurement invariance

We conducted multiple-group CFA and measurement invariance on the 3- and 4-factor solutions of the MMQ. Individual group factor loadings for both models are reported in Table 2.2. Model fit and measurement invariance results for the 3- and 4-factor solutions are reported in Tables 2.3 and 2.4, respectively.

Table 2.2. CFA results for 3- and 4-factor loadings in young and older adults

		MMQ-Satisfaction Factor Loadings	
MMQ-Satisfaction items		YA	OA
1	Generally pleased with my memory	.691	.797
2	Something wrong with my memory	.674	.623
3	If important, I'll remember it	.356	.404
4	Fear that I have serious memory problem	.477	.736
5	My memory is worse than others	.799	.522
6	Confidence in my abilities	.715	.718
7	Unhappy when I think about my memory	.806	.954
8	Worry that others will notice my memory	.698	.804
9	I'm not too hard on myself	.163	.423
10	Concerned about my memory	.769	.958
11	Memory is going downhill	.654	.793

12	Generally satisfied with my memory	.743	.805
13	Not upset when I forget	.287	.485
14	Worry that I will forget important things	.438	.698
15	Embarrassed about my memory	.706	.818
16	Annoyed with myself when I forget	.391	.548
17	My memory is good compared to others	.710	.624
18	Worry about my memory	.800	.995
MMQ-Ability Factor Loadings			
	MMQ-Ability items	YA	OA
1	Forget to pay bills	.415	.325
2	Misplace everyday items	.550	.561
3	Trouble remembering a telephone number	.649	.518
4	Not recall names	.589	.502
5	Leave things behind	.621	.496
6	Forget an appointment	.524	.453
7	Forget what you were about to do	.663	.502
8	Forget an errand	.624	.500
9	Difficulty coming up with words	.586	.454
10	Trouble remembering details from article	.630	.557

11	Forget medication	.526	.321				
12	Not recall a familiar name	.528	.462				
13	Forget to give a message	.642	.466				
14	Forget what you were saying	.634	.470				
15	Forget a birthday	.579	.519				
16	Forget a telephone number	.521	.534				
17	Retell a story	.631	.425				
18	Misplace something you put away	.706	.552				
19	Forget to buy something	.710	.565				
20	Forget a conversation	.659	.518				
MMQ-Strategies Factor Loadings							
		All Strategies		External Strategies		Internal Strategies	
	MMQ-Strategies items	YA	OA	YA	OA	YA	OA
1	Use a timer	.437	.457	.587	.569		
2	Ask someone to help you remember	.306	.309	.316	.321		
3	Create a rhyme	.611	.412			.684	.473
4	Create an image	.660	.549			.708	.614
5	Write on a calendar	.407	.132	.616	.220		
6	Go through the alphabet	.302	.430			.348	.438

7	Organize information	.678	.729		.639	.709
8	Say something out loud	.669	.702		.661	.661
9	Use a routine	.494	.550	.593	.565	
10	Make a list	.540	.281	.767	.489	
11	Mentally elaborate	.835	.598		.840	.640
12	Put something in prominent place	.599	.459	.647	.559	
13	Repeat something to yourself	.810	.578		.874	.634
14	Create a story	.755	.541		.857	.634
15	Write in notebook	.765	.523	.799	.671	
16	Create acronyms	.674	.413		.721	.472
17	Concentrate hard	.743	.544		.750	.535
18	Write a note for yourself	.612	.580	.826	.759	
19	Mentally retrace your steps	.601	.473		.560	.415

2.3.3 *MMQ 3-factor solution*

Before performing measurement invariance testing, we tested the baseline configural 3-factor models in each group separately. The young adults' 3-factor configural model did not meet our criteria for acceptable fit, with CFI and TLI falling below .95; however, absolute fit indices RMSEA and SRMR were accepted as they were inferior to .10 and .08, respectively. In older adults, both absolute fit indices indicated good absolute fit of the 3-factor model. Comparative fit indices were higher than in the young adult group. Although they did not reach

our conservative cutoff of .95, these values were closer to those reported by Shaikh et al. (2021a), i.e., CFI = .90, TLI = .89, as well as absolute fit values RMSEA = .05 and SRMR = .08.

Measurement invariance was then performed to statistically compare the young adults' 3-factor MMQ model fit with that of the older adults. We first assessed the configural invariance of our model to determine whether the loading patterns were equivalent between groups. Both absolute fit indices met our cutoff criteria of .10 and .08, respectively, but CFI and TLI did not as they were inferior to .95. Because we did not find support for configural invariance, we assumed that the MMQ factor structure was non-invariant across age groups (Putnick & Bornstein, 2016) and proceeded to our next set of analyses (for those who are interested, we reported our metric, scalar, and residual invariance results in Table 2.3).

Table 2.3. Measurement invariance results for the MMQ 3-factor solution

3-Factor MMQ Model Invariance							
Fit statistic	Overall	YAs	OAs	M1: Configural	M2: Metric	M3: Scalar	M4: Residual
χ^2 (<i>df</i> , <i>p</i>)	5687.28 (1536, <.001)	3926.45 (1536, <.001)	2976.53 (1536, <.001)	6902.97 (3072, <.001)	7067.60 (3126, <.001)	8584.55 (3180, <.001)	8039.26 (3183, <.001)
CFI	.756	.747	.810	.775	.768	.683	.715
TLI	.746	.737	.802	.766	.764	.681	.714
RMSEA [90% CI]	.061 [.059, .062]	.062 [.059, .064]	.054 [.051, .056]	.058 [.056, .060]	.059 [.057, .060]	.068 [.066, .070]	.064 [.063, .066]
SRMR	.071	.073	.073	.073	.078	.086	.091
Model comparison	—	—	—	—	M1	M2	M3
$\Delta\chi^2$ (Δdf)	—	—	—	—	164.63 (54)	1516.95 (54)	545.29 (3)
ΔCFI	—	—	—	—	.007	.085	.032
ΔTLI	—	—	—	—	.002	.083	.033
ΔRMSEA	—	—	—	—	.001	.009	.004
ΔSRMR	—	—	—	—	.005	.008	.005
<i>Note.</i> CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, TLI = Tucker-Lewis index.							

2.3.4 MMQ 4-factor solution

The same steps as above were followed to evaluate the age invariance of the 4-factor solution. First, we tested the baseline configural 4-factor models for young and older adult

groups, separately. In line with our results for the 3-factor model, fit indices CFI and TLI indicated poor configural model fit for young adults, although RMSEA and SRMR values were accepted. In older adults, CFI and TLI values approached acceptable fit, and RMSEA and SRMR values indicated good absolute fit. Older adults' model fit values were close to those reported by Shaikh et al. (2021a) for their 4-factor solution, i.e., CFI = .91, TLI = .90, RMSEA = .05, and SRMR = .07. Overall, the configural model fit for the 4-factor model was qualitatively better than that of the 3-factor model for both the young and older adults.

Next, we assessed configural invariance of our 4-factor model. Once again, RMSEA and SRMR values met our criteria for acceptable fit, although CFI and TLI values did not. Therefore, configural invariance of our 4-factor model was not supported (see Table 2.4 for metric, scalar, and residual invariance results).

Table 2.4. Measurement invariance results for MMQ 4-factor solution

4-Factor MMQ Model Invariance							
Fit statistic	Overall	YAs	OAs	M1: Configural	M2: Metric	M3: Scalar	M4: Residual
$\chi^2 (df, p)$	5278.48 (1533, <.001)	3749.52 (1533, <.001)	2821.47 (1533, <.001)	6750.99 (3066, <.001)	6733.01 (3119, <.001)	8046.60 (3172, <.001)	7699.01 (3176, <.001)
CFI	.780	.765	.830	.794	.788	.714	.734
TLI	.771	.756	.823	.786	.783	.712	.733
RMSEA [90% CI]	.058 [.056, .059]	.060 [.057, .062]	.051 [.048, .054]	.056 [.054, .058]	.056 [.054, .058]	.065 [.063, .066]	.062 [.060, .064]
SRMR	.071	.072	.073	.072	.077	.086	.089
Model comparison	—	—	—	—	M1	M2	M3
$\Delta\chi^2 (\Delta df)$	—	—	—	—	17.98 (53)	1313.59 (53)	347.59 (4)
ΔCFI	—	—	—	—	.006	.074	.020
ΔTLI	—	—	—	—	.003	.071	.021
$\Delta RMSEA$	—	—	—	—	.000	.009	.003
$\Delta SRMR$	—	—	—	—	.005	.009	.003

Note. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, TLI = Tucker-Lewis index.

2.3.5 MMQ correlations with CES-D

We conducted two-tailed Pearson correlations between CES-D scores and MMQ scales in young adults and older adults, separately. In both young and older adults, CES-D scores were significantly inversely correlated with MMQ-Satisfaction and MMQ-Ability. Young adults' CES-D scores were also positively correlated with MMQ-Strategies, including both External and Internal subscales; however, in older adults, the associations with MMQ-Strategies and its subscales were not significant. All correlations are reported in Table 2.5.

Table 2.5. Correlations between CES-D and MMQ in young and older adults

		Young adults (N = 144)				
		MMQ-Satisfaction	MMQ-Ability	MMQ-Strategies	MMQ-External Strategies	MMQ-Internal Strategies
CES-D score	Pearson's r	-0.395***	-0.300***	0.221**	0.198*	0.190*
	p-value	< .001	<.001	0.007	0.016	0.020
	95% CI Upper	-0.250	-0.146	0.369	0.348	0.341
	95% CI Lower	-0.523	-0.440	0.062	0.038	0.030
		Older adults (N = 208)				
		MMQ-Satisfaction	MMQ-Ability	MMQ-Strategies	MMQ-External Strategies	MMQ-Internal Strategies
CES-D score	Pearson's r	-0.344**	-0.220**	-0.024	-0.086	0.024
	p-value	< .001	0.001	0.737	0.222	0.731
	95% CI Upper	-0.217	-0.086	0.114	0.052	0.160
	95% CI Lower	-0.459	-0.347	-0.160	-0.220	-0.113

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

2.4 Discussion

The MMQ is a well-established and widely used measure of subjective memory in older adults (Troyer & Rich, 2002) and although it has been used repeatedly in its original form with younger populations (Csábi et al., 2023; Ling et al., 2020; Raimo et al., 2016; Ryan & Campbell, 2024; Singer et al., 2005; van der Werf & Vos, 2011), its psychometric properties have not yet

been verified across age groups. Here, we independently tested the MMQ factor structure in a large sample of young and older adults. We also compared young and older participants' responses on individual MMQ items and formally assessed the age-invariance of the MMQ using multiple-group CFA and measurement invariance for the first time.

2.4.1 Age comparisons on the MMQ

The young adults in our sample indicated that they were more satisfied with their memory and used strategies more often than the older adults. These age-related differences on MMQ-Strategies were driven by young adults' greater self-reported use of internal strategies (as opposed to external strategies) compared to older adults. This finding may in part be explained by the fact that all the young adults in our sample were university students at the time of testing and were probably more likely to use cognitive/mnesic strategies to help their academic performance compared to older adults and non-students (see Karr, 2022). Independent *t*-tests on each of the items showed that young and older adults differed significantly in their responses to approximately two-thirds of the MMQ items (i.e., 37 out of 57 items). As far as we are aware, no previous studies have looked at age differences on the original MMQ scales. However, our findings are in line with van der Werf and Vos (2011) who found that, in their sample ranging from 18 to 89 years old, age was inversely (albeit weakly) correlated with MMQ-Satisfaction and MMQ-Strategies but showed no significant association with MMQ-Ability. Other studies that have included young participants have found somewhat different associations with the MMQ scales (Csábi et al., 2023; Raimo et al., 2016).

Our confirmatory factor analysis results did not support the previously reported 3- and 4-factor MMQ solutions in our full sample, so we tested the age-invariance of the scale's factor structure. Both the 3- and 4-factor structures of the MMQ were supported in the older adult

sample (consistent with Csábi et al., 2023; Fort et al., 2004; Raimo et al., 2016; Shaikh et al., 2021a; van der Werf & Vos, 2011) but not in the young adult sample. This suggests that the original MMQ scales are not age-invariant, meaning that they may measure different (even if only slightly) constructs in young adults and older adults.

Modifications of MMQ items may render the tool more appropriate for use in young adults. Our factor analysis and measurement invariance results are in part consistent with Karr (2022) who found that the MMQ-Strategies factor structure did not show excellent model fit in a sample of young adults. This led the author to suggest that the scale would benefit from some modifications and, potentially, the addition of items that would be equally relevant to both young and older adults. For example, the use of technology as a type of external memory strategy may be particularly relevant for younger generations (Radnan et al., 2023), but are becoming increasingly relevant for older generations too. Any adult age differences in this technology use may disappear in the future as new cohorts of older adults become increasingly likely to use digital memory aids (as discussed by Hertzog et al., 2019).

Other possible scale modifications relate to the length of the scale. The entire MMQ consists of 57 questions and can take a relatively long time to administer (approximately 10 minutes in healthy populations, and even longer in people with cognitive impairment; Troyer & Rich, 2002), which may not be feasible or affordable, especially if administered as part of a larger battery within the same testing period. A shorter version would save time and energy in administration, scoring, data entry, and analysis in all ages, as has previously been done with other subjective memory scales (e.g., Metamemory in Adulthood Questionnaire [Campelo et al., 2016; McDonough et al., 2020]; Memory Functioning Questionnaire [Zelinski & Gilewski, 2004]). Ideally, the MMQ would also be optimized for use in young adults (see Karr, 2022), but

this is in the hands of the questionnaire authors. Alternatively, if one's main goal were to compare young and older adults, one could use one of the handful of metamemory questionnaires that have included both young and older (and, ideally, middle-aged) adults in their creation and norming (e.g., Metamemory in Adulthood Questionnaire [Dixon & Hultsch, 1988]; Memory Functioning Questionnaire [Gilewski et al., 1990]; Prospective and Retrospective Memory Questionnaire [Smith et al., 2000]; Everyday Memory Questionnaire [Sunderland et al., 1983]).

2.4.2 Associations with mood/depression

In our sample, CES-D mood ratings were associated with the MMQ scales, which is consistent with previous studies (Chin et al., 2014; Csábi et al., 2023; Fort et al., 2004). In both age groups, CES-D was inversely correlated with MMQ-Satisfaction and MMQ-Ability, suggesting that lower mood is related to lower overall contentment with one's memory and more frequently reported memory mistakes in both young and older adults. As Chin et al. (2014) note, low mood – especially in older adults – may be related to deficits in cognitive functions such as executive function, speed of information processing, and memory. Additionally, in the present dataset, CES-D scores were positively correlated with MMQ-Strategies (including both Internal and External subscales) in the young adults, but this association did not reach statistical significance in the older adults. It is therefore possible that higher self-reported depressive symptoms in young adults, specifically undergraduate students, contributed to the age-invariance of the MMQ, especially considering that they had significantly greater CES-D scores than older adults to begin with (see Table 2.1). However, it should be noted that only half of our participants completed the CES-D; therefore, these findings may not apply to the entire sample. Future studies are needed to further investigate the relationship between mood and subjective

memory and consider the influence of other individual-level variables that might modulate this relationship, such as sex and personality (discussed in more detail below).

2.4.3 Strengths, limitations, and future directions

To the best of our knowledge, ours is the first study to address the age-invariance of the MMQ. Additionally, our community-dwelling older adults were characterized in terms of their cognitive functioning with the MoCA, which provided additional evidence that they were all within the cognitively normal range. Besides ours, only a few studies on normal cognitive aging that employed the MMQ have also included the MoCA. For instance, Raimo et al. (2016) found positive, albeit weak, correlations between the MoCA and MMQ scales (all $r < .30$), indicating that individuals with better general cognition had somewhat better self-reported memory. However, the comparison of our findings to previous ones is complicated by the fact that these studies have screened participants using different cutoffs, e.g., 23 (Shaikh et al., 2021a), 17 (Yang et al., 2023), or 15.5 (Raimo et al., 2016) and thus had older adult samples with different ranges of cognitive impairment.

Two potential limitations of our study pertain to our young adult participants. First, all were university students, so their subjective memory responses may not generalize to the rest of the young adult population. Future studies could consider recruiting more representative samples from the broader community. Second, a portion of our young adult participants completed the MMQ online (due to difficulties with in-person recruitment), whereas the rest of the young and all the older adults were tested in-lab. The young adults evaluated online reported significantly more memory mistakes than those tested in-person, as demonstrated by their lower MMQ-Ability scores. It seems likely that this difference was caused by factors other than the different testing modalities used, as both groups had similar scores on the other two MMQ scales (see

Appendix A1). Furthermore, previous studies have administered the MMQ online and have found somewhat similar results to ours (Csábi et al., 2023; van der Werf & Vos, 2011). Other studies have also directly compared the validity of in-person and online self-evaluation psychological surveys and found that both modalities yield equivalent responses (e.g., Arrow et al., 2023; Weigold et al., 2013; Zager Kocjan et al., 2023). Besides the difference in testing modalities, the only other obvious distinction between participants from our archival dataset and our new online sample is that the latter was exposed to the COVID-19 pandemic prior to answering the MMQ. Therefore, we hypothesize that these differences in MMQ-Ability may have been related either directly to possible exposure to the coronavirus or indirectly via changes in objective cognitive performance following COVID-19 infection (Akinci et al., 2023; Guo et al., 2022; Herrera et al., 2023; Velichkovsky et al., 2023) or other related factors such as stress (Orrù et al., 2023; Podlesek et al., 2021), which may have in turn influenced their perceived frequency of memory lapses/mistakes. However, we did not collect data on participants' exposure to COVID-19, nor did we evaluate their objective memory performance, so this hypothesis has yet to be explored.

Another limitation lies in the general use of subjective memory questionnaires. Although such scales are practical in many research and clinical contexts, the subjective memory complaints endorsed on a questionnaire may not always capture the full extent of concerns that people may have about their memory. For instance, Burmester et al. (2015) compared the content and frequency of subjective memory complaints reported in response to an open-ended question versus items from structured subjective memory questionnaires (including MMQ-Ability) in their sample of middle-aged and older adults. Participants endorsed more memory complaints on a checklist than they reported spontaneously in response to an open-ended question. Yet, the

open-ended questions elicited a greater variety of reported subjective memory complaints than did the structured questionnaires. Another method of assessing subjective memory that may be more informative than structured questionnaires is the collection of daily diaries and ecological momentary assessments. Using the former technique, Mogle et al. (2023) found that older adults reported more retrospective memory lapses than young adults (age range = 25–91 years). In this study, sex differences were also observed, with females reporting more frequent and impactful prospective memory lapses than males (discussed in more detail below). Given that unstructured/open-ended measures may provide additional, valuable information about one's self-reported memory than structured scales, future studies should consider combining such methods with the MMQ.

In following up to understand why the original MMQ factor structures were replicated in our older adults but not in our young adults, it may be helpful to consider two additional sociodemographic/psychological factors: sex and personality. Participant sex has previously been associated with MMQ scores (Csábi et al., 2023; Raimo et al., 2016; van der Werf & Vos, 2011; but see Troyer & Rich, 2002) and, compared to males, females have reported lower memory satisfaction and memory ability but greater use of internal and external memory strategies on the MMQ (Csábi et al., 2023; van der Werf & Vos, 2011). These sex effects are corroborated by larger studies using subjective memory assessments other than the MMQ (Derouesné et al., 1999; Parisi et al., 2011; Tomita et al., 2014; Van der Elst et al., 2011; for a review, see Jonker et al., 2000) and contrast with females' greater objective memory performance than males (for meta-analyses, see Asperholm et al., 2019; Hirnstein et al., 2023; Voyer et al., 2007). The greater prevalence of memory complaints among females may be related to their tendency to report their health concerns more often than males (Fritsch et al., 2014; Jonker et al., 2000; see discussion

from Raimo et al., 2016). It is also possible that older females, who are at higher risk of developing Alzheimer's Disease than males (Ferretti et al., 2018; Mielke et al., 2014), are aware of this fact and consequently express more cognitive concerns (Cantegreil-Kallen & Pin, 2012; Kinzer & Suhr, 2016; Norman et al., 2020; Werner et al., 2013; Wu et al., 2009; but see Cutler, 2015; Roberts et al., 2014). Subjective memory may also be modulated by sex (relating to our biological attributes) and gender (relating to our sociocultural identities and roles) differences in other psychological factors such as certain personality traits (Costa et al., 2001; Mac Giolla & Kajonius, 2019) and mood disorders (e.g., anxiety, depression; Eid et al., 2019; McLean et al., 2011; Salk et al., 2017).

Personality may also be related to subjective memory ratings; however, to the best of our knowledge, no published studies have yet examined the associations between personality traits and the MMQ specifically. Previous studies using subjective memory questionnaires other than the MMQ have suggested that neuroticism is related—although not necessarily directly so—to subjective memory complaints in both young (e.g., Pearman, 2009) and older adults (e.g., Hülür et al., 2015; Steinberg et al., 2013). Other aspects of personality may be important, too (Haavisto et al., 2020; Hill et al., 2024; Hülür et al., 2015; Pearman, 2009; Pearman & Storandt, 2004; Slavin et al., 2010; Steinberg et al., 2013). Overall, personality appears to be a strong predictor of subjective memory (Aschwanden et al., 2020), perhaps even stronger than is objective memory ability (Slavin et al., 2010).

2.4.4 Conclusion

The present data have provided insight into how young and older adults respond on the MMQ, and how the questions are related to one another in each age group. Our results suggest that young adults, specifically undergraduate students, report their memory satisfaction and

strategies to be somewhat different from those of older adults; it was therefore not surprising that the two age groups' answers often differed. Perhaps more surprisingly, the relations among the answers (i.e., the factor structure) differed somewhat between the two age groups. If one wanted to compare young and older adults' subjective memory, the MMQ does reasonably well at present (and has been employed with young adults by Csábi et al., 2023; Ling et al., 2020; Raimo et al., 2016; Ryan & Campbell, 2024; Singer et al., 2005; van der Werf & Vos, 2011); however, to make a close comparison of young and older adults, it might be worth considering the age-invariance of the scale and how the MMQ might interact with other factors that change with age, such as self-reported mood and depression. Alternatively, the MMQ could be modified for use with young adults by its creators. Additionally, to better understand how age relates to subjective memory ratings, future studies with any metamemory questionnaire should further investigate the potential influence of different sociodemographic and psychological variables, such as sex, mood/depression, and personality factors, in both young and older adults.

2.5 Acknowledgments

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2.6 Data availability statement

All study data and materials will be made available upon request via email using a secure link.

2.7 Declaration of Interests

The authors report there are no competing interests to declare.

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Study 2 – The development of a remotely administered episodic memory battery for repeated use (Unpublished pilot study)

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2.8 Introduction

Pre-2020, our lab had used Glisky et al.'s two-factor neuropsychological battery to study episodic memory and executive control in a traditional laboratory setting, primarily with older adults. With the arrival of COVID-19, we were forced to adapt our testing approach to online settings. In response to this sudden need for remote participant testing, we developed a web-based version of Glisky et al.'s battery and made a few more modifications, including switching out some widely used episodic memory tests (e.g., Wechsler's Logical Memory) with ones from the experimental literature that were arguably more suitable for online testing. We recently administered this new neuropsychological battery to healthy young and older adults via videoconference and found that its two-factor structure held up well in older adults but less so in young adults, due in large part to certain tasks not fitting well with the others (i.e., Wisconsin Card Sorting Test [WCST] and Brown Location Test [BLT]) (Jensen et al., 2025).

In Study 3 of the present thesis, we aimed to use our lab's remote two-factor neuropsychological battery (Jensen et al., 2025) to examine potential OC-related changes in cognition in young adults across two separate time points. Because our recent study findings suggested that our battery should further be modified prior to its use with young adults—and, moreover, because Study 3 required the use of parallel forms of the individual memory tasks—we therefore made some additional modifications to the battery and tested it with a small sample of young adult participants.

In the present pilot study, we first removed the BLT and WCST from the episodic memory and executive control composites, respectively, because these tasks did not load significantly onto their respective factors in young adults (Jensen et al., 2025). Second, we developed parallel/equivalent forms of the episodic memory tasks to allow participants to complete two separate versions of the battery (i.e., one at each testing session) in Study 3. Third, we updated the remote, videoconference-based tasks to be self-administered. Finally, because this thesis is focused on young adults—particularly young females—we limited recruitment for the present pilot study to young adults.

The analyses included in the present study aimed to 1) examine the relations among the individual episodic memory tasks in each study version (i.e., parallel forms), 2) compare participant performance on the two versions of the episodic memory battery, and 3) compare participant performance on the two modalities (i.e., self- vs. videoconference administration) of the two-factor battery. Additionally, to further examine how the tasks in our updated episodic memory battery fit together in young adults, we conducted a factor analysis with the young adult data from Jensen et al. (2025) using only the tasks included in the present pilot study's updated battery (i.e., excluding the BLT and WCST).

2.9 Method

2.9.1 *Participants*

Between February and April 2023, a total of $N = 50$ undergraduate students were recruited from ISPR, the University of Ottawa's undergraduate participant pool. An a priori power analysis using G*Power revealed that $N = 46$ would offer 95% power in a one-tailed Pearson correlation with $\alpha = .05$ to detect a medium-sized effect of $r = .50$.

Participants received one ISPR credit for taking part in the study. The sample consisted of fluent English speakers (determined based on a prescreen question in the ISPR portal) and was balanced in terms of participant sex, i.e., $n = 26$ females and $n = 24$ males. Participant demographics are reported in Table 2.6.

Table 2.6. Participant demographics (collapsed across study modality and version)

Demographic variable		M (SD) or N (%)
Age (years)		20.4 (4.53)
Education (years)		13.3 (1.60)
Sex		
	Female	26 (52%)
	Male	24 (48%)
First language		
	English	33 (66%)
	French	1 (2%)
	Other	16 (32%)

2.9.2 *Episodic memory battery*

Episodic memory, a subtype of explicit memory, refers to the ability to recall specific events or experiences, canonically comprising contextual details including time and place (Tulving, 1972). Immediate and delayed recall tasks are commonly used to assess episodic memory performance, tapping short-term and long-term memory processes, respectively. These systems are thought to rely on distinct mechanisms (Atkinson & Shiffrin, 1968). Short-term memory acts as temporary storage for new information and is often considered part of the working memory system, which also supports the manipulation of information in memory (Baddeley, 2000). Within Baddeley's (2000) updated model of working memory, the episodic

buffer is a limited-capacity system that integrates verbal and visual inputs in short-term memory into coherent episodes, which can then be encoded as episodic memories in long-term memory.

To qualify as episodic, a memory must include both the event and contextual details at the time of retrieval and involve a subjective sense of “time travel” (Tulving, 2002). Delayed recall, which relies particularly heavily on the hippocampus/MTL (Vargha-Khadem et al., 1997), reflects these key features. Accordingly, the present episodic memory battery prioritized the delayed recall features of component tasks, as they more accurately represent the central features of episodic memory (although it should be noted that none of these tasks assess Tulving’s subjective sense of “time travel”).

The episodic memory battery used in the present pilot study was derived from Jensen et al. (2025) which used a modified version of Glisky et al.’s (1995, 2001) episodic memory composite, initially constructed to reflect hippocampal/MTL-dominant processes. The present, updated battery includes delayed recall of Face-Name Paired Associates (FNPA; Caillaud et al., 2020), Verbal Paired Associates (VPA; Uttl et al., 2002), and two Taler Stories (Taler et al., 2021), and immediate recognition of the Four Mountains Task (4MT; Chan et al., 2016).

2.9.2.1 Face-Name Paired Associates (FNPA)

We modified the original FNPA (Caillaud et al., 2020) materials to include a set of more racially representative faces from Bainbridge et al. (2013). Face images had no significant identifiers (e.g., makeup, accessories, facial hair), had a neutral expression, and were not from well-known celebrities. The final materials consisted of nine faces, including five females and four males of various races. The colour and background of each image were edited to resemble the formatting of the original materials (i.e., greyscale, black background).

During the encoding phase, nine black-and-white face-name pairs are shown on the screen one at a time (for 8 seconds each) and participants are instructed to remember the name that corresponds to each face. Each face-name pair appears only once. Immediately following the encoding phase is the first retrieval phase, wherein participants are shown the same faces again and are asked to recall the name that is associated with each face. After a 20-minute delay, participants must complete the delayed recall phase in which they are again asked to recall the name associated with each face. Scores consist of the total number of correctly recalled names for the immediate and delayed conditions (both out of nine).

We recently administered the original version of FNPA to young adults via videoconference and found that delayed FNPA recall was positively correlated with delayed story recall ($r = .30$; Jensen et al., 2023). Although the reliability of the videoconference-administered version of FNPA has not yet been formally examined, previous studies have demonstrated that other face-name association tasks, such as FNAME (Papp et al., 2014), have high ecological validity and test-retest reliability (Amariglio et al., 2012; Papp et al., 2014) and show age differences in performance (Enriquez-Geppert et al., 2021). The remotely administered version of the FNAME also has good reliability in online settings and is positively correlated with its in-lab computerized version (mean $r = .62$, Rentz et al., 2025).

2.9.2.2 Verbal Paired Associates (VPA)

This 15-item version of the VPA was adapted from the Wechsler Memory Scale-Revised (WMS-R; Utzl et al., 2002). It uses all eight original word pairs from the WMS-R, including four easy, semantically related pairs (e.g., sky-cloud) and four difficult, semantically unrelated pairs (e.g., hot-quiet), mixed with an additional seven difficult, unrelated pairs. This task consists of two immediate and two delayed recall trials. In the initial encoding phase, participants are

presented with two trials of fifteen word pairs shown in different orders. For the immediate recall trials, the first word of each pair is presented again, and participants are required to recall the second word of each pair. After a 20-minute delay, participants must complete two delayed recall trials, for which they are once again presented with the first word of each pair (presented in a different order). Immediate and delayed recall scores are calculated by summing the total number of word pairs recalled correctly for the immediate and delayed trials, respectively. The web-based administration of VPA cued recall has yielded similar results to in-person (Cyr et al., 2021; Rizzi et al., 2023) and has shown significant positive correlations with its in-person equivalent ($r = .67$, Cyr et al., 2021).

The VPA task used in Jensen et al. (2025) consisted of two encoding and recall trials for the immediate condition and two recall trials for the delayed condition. Participants, young adults especially, performed near the ceiling; therefore, to minimize ceiling effects, we reduced this task to one learning trial and one recall trial for the immediate condition and one recall trial for the delayed condition.

2.9.2.3 Story recall

We used two stories from Taler et al. (2021). Participants watch video recordings of an experimenter reciting two short (60- to 69-word) passages in succession and are asked to intentionally recall each story immediately after hearing them and again after a 20-minute delay. Participants' immediate and delayed responses for each story are then transcribed and scored according to the number of units (i.e., words) recalled, wherein each unit is categorized as either veridical (i.e., word-for-word), gist (i.e., essential meaning), or distortion (i.e., incorrect meaning). For each type of scoring, mean scores are calculated across the two stories, separately for immediate and delayed recall. Here, we used the veridical, unit-based scoring method

because this is most similar to the method used for Wechsler's Logical Memory. Recall of Taler et al.'s stories is significantly correlated with Logical Memory in young adults, cognitively intact older adults, and those with mild cognitive impairment (Taler et al., 2021). No studies have yet examined the reliability of the remote administration of this particular task; however, recent studies have found that the videoconference and in-person versions of delayed Wechsler Logical Memory (which is very similar to Taler et al.'s method) were equivalent in healthy adults (Krynicky et al., 2023; Varandas et al., 2024). Additionally, the remote administration of a story recall task was also positively correlated with the traditional administration of Wechsler's Logical Memory in a sample of older adults without cognitive impairment ($r = .35$; Skirrow et al., 2022). We also recently administered the present story recall task to young adults via videoconference and found that both the immediate and delayed recall scores were positively correlated with FNPA delayed recall scores ($r = .30$; Jensen et al., 2023).

2.9.2.4 *Four Mountains Task (4MT)*

We used Burles & Iaria's (2020) implementation of the computerized 4MT (Chan et al., 2016). Participants are first shown a target image of a mountain range landscape for a duration of eight seconds. Following a two-second delay, they are shown four similar images, including one that depicts the same mountain range in the target image but from a different viewpoint, and the rest of which are foil images of mountain ranges differing in topological characteristics (i.e., viewpoints, colours, and textures). Participants must complete three practice trials, during which feedback is provided, followed by 20 test trials. The number of correct responses made on each of the test trials is then summed into a total score, ranging from 0-20, with higher scores representing better performance. The remote/web-based version of the 4MT has been used

previously (Brown et al., 2023; Burles & Iaria, 2020) and has moderate test-retest reliability (Coughlan et al., 2023).

2.9.2.5 Episodic memory parallel forms

Parallel forms for 4MT and Story Recall were made available by the authors, whereas parallel forms of the FNPA and VPA were not yet developed. For FNPA, we retrieved nine new images of faces from Bainbridge et al. (2013) and matched them with the original set on gender, age, and race. For VPA, we created a new 15-pair word list and matched it to the original set on word frequency, length, and type (e.g., noun versus verb), as well as number of syllables and imageability.

2.9.3 Executive control battery

The executive control tasks came from Glisky and colleagues' original battery (Glisky et al., 1995, 2001; Glisky & Kong, 2008) consisting of four tests known to be sensitive to frontal lobe function (MacPherson et al., 2015): Mental Control and Backward Digit Span from WMS-III (Wechsler, 1997), Verbal Fluency to letters F, A, and S (Spreen & Benton, 1977), and number of categories achieved on Wisconsin Card Sorting Test (WCST; Steinke et al., 2021). Note that parallel forms of the executive control tasks were not used or developed here because executive control is only assessed at baseline in Study 3.

2.9.3.1 Mental Control

This task consists of eight brief items (e.g., counting from 1 to 20 forward and backward). Each item is scored out of five according to the number of mistakes made and the duration of the participant's timed response, for a maximum score of 40. Both the traditional, in-person version and the videoconference version of Mental Control are correlated with other executive control tasks in our battery (Davidson & Jensen, 2022; Jensen et al., 2023). To the best

of our knowledge, no other studies besides ours have administered Mental Control via videoconference (Jensen et al., 2023), and none have yet examined its reliability.

2.9.3.2 Digit span

This task consists of two conditions: forward and backward. In the backward condition, participants hear seven pairs of two digit sequences of increasing length and must repeat these sequences back in the reverse order, for a maximum score of 14. In both conditions, the task ends after the participant says two sequences wrong within the same pair.

We previously administered this task over videoconference to young adults and found that it was strongly related to the other executive control tasks in our battery (Jensen et al., 2023). Videoconference- and lab-administered Digit Span were also equivalent in studies with healthy adults (M age = 21: Bartholomaeus et al., 2024; M age ~ 40; Krynicki et al., 2023; M age = 23; Mahon et al., 2022). Mahon et al. (2022) also found that the in-person and remote versions of this task were strongly correlated ($ICC = .96$). The web-based/remote version of Backward Digit Span yielded similar performance to the traditional version in a sample of young adults (Leong et al., 2022) and in a sample of adults of all ages (Haas et al., 2022); in this last study, both task versions shared a positive correlation ($\rho = .39$).

2.9.3.3 Verbal fluency

Across three separate trials corresponding to the letter cues F, A, and S, participants must produce as many words (i.e., common nouns, excluding words that share a common root with others) as possible starting with the letter, within 60 seconds. The number of eligible words produced in response to each letter cue is summed to make a total score. Meta-analysis has shown that verbal fluency administered via videoconference is equivalent to the traditional version (Brearly et al., 2017).

2.9.4 Procedure

Two studies, including one online/remote study and one videoconference-based study, were posted on the ISPR portal. Participants were invited to sign up for the study modality of their choice and were then randomly assigned to one of two study versions. The order in which individual tasks were presented was also counterbalanced across participants. In each case, participants first completed a prescreening questionnaire (which collected demographic information including age, sex, years of education, and first spoken language), the executive control battery, and one version of the episodic memory battery. Table 2.7 below indicates the number of study participants broken down by study modality and version.

In the videoconference study, all tasks were administered as described above. In the online/remote version, all tasks were developed using Gorilla Experiment Builder (<https://app.gorilla.sc>) and participants completed them independently.

Table 2.7. Sample sizes by study modality and version

	Online/remote	Videoconference	<u>Total</u>
Version 1	10	10	20
Version 2	21	9	30
<u>Total</u>	31	19	50

Note. The online/remote Version 1 of Story Recall was accidentally administered to $n = 11$ participants instead of Version 2. To correct this, we administered Version 2 of Story Recall to $n = 10$ additional participants and merged these with the rest of the dataset, bringing the total sample size to $N = 50$.

2.9.5 Data analysis

First, one-tailed Pearson correlations were performed on the individual tasks in our episodic memory battery to qualitatively compare the associations across the tasks in each study version (i.e., parallel forms). Second, independent samples t -tests were used to compare participant performance across the two versions of the episodic memory battery. t -tests were also

used to compare participant performance on the entire two-factor battery across the two study modalities (i.e., online/remote vs videoconference) and to compare performance between male and female participants on the episodic memory battery. Finally, to predict how the individual tasks in our modified episodic memory battery might fit together in a larger sample of young females (such as Study 3), a two-factor CFA was conducted using the data from the $n = 62$ young female participants from Jensen et al. (2025). For this analysis, we followed the same procedures and used the same metrics for CFA as in our previous study (Jensen et al., 2025).

2.10 Results

2.10.1 Correlations across episodic memory tasks

Three sets of one-tailed Pearson correlations between the individual episodic memory tasks were conducted to qualitatively compare the strength of such relations across the two study versions. The first set of analyses, which was collapsed across testing modalities due to small sample sizes, revealed similar relationships between each pair of tasks in the episodic memory battery (see Table 2.8). Although they were not all statistically significant, all correlations except for one—that is, Version 2 of 4MT and FNPA—were positive, indicating that the episodic memory tasks share linear, positive relationships with one another across both study versions. Additionally, none of these correlations appeared to differ across study versions (all $p > .11$).

Table 2.8. Pearson correlations between individual episodic memory tasks by study version

	FNPA Del.		VPA Del.		Story Recall Del.		4MT	
	V1	V2	V1	V2	V1	V2	V1	V2
FNPA Del.	-	-						

VPA Del.	0.39	0.14	-	-				
Story Recall Del.	0.33	0.20	.56*	0.25	-	-		
4MT	0.04	-0.29	0.41	0.11	0.36	0.13	-	-

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

2.10.2 Comparisons of study versions

Three sets of independent samples t -tests were conducted to directly compare participants' performance on the two versions of the episodic memory battery. The first set, which was collapsed across testing modalities (i.e., videoconference and online/remote), revealed that performance on individual episodic memory tasks did not significantly differ by study version (all $p > .05$). Although these differences were not statistically significant, Version 1 of FNPA and Story Recall yielded slightly higher scores than Version 2 of these tasks. Results are reported in Table 2.9.

Table 2.9. Comparisons of episodic memory tasks by study version

Episodic memory task	Study version	M	SD	t (df)	p	d
FNPA Del.	1	6.50	1.99	1.05 (38)	0.300	0.33
	2	5.85	1.93			
VPA Del.	1	6.25	3.81	0.00 (38)	1.000	< .001
	2	6.25	3.73			
Story Recall Del.	1	18.73	5.27	0.99 (44)	0.329	0.30
	2	17.24	4.50			
4MT	1	11.40	3.00	0.60 (38)	0.551	0.19
	2	10.75	3.78			

The second and third sets of *t*-tests, which were limited to the online/remote sample and videoconference sample, respectively, also did not reveal any significant differences between study versions on any of the individual memory tasks. Notably, the slight difference on FNPA identified in the combined sample was absent in the online sample (see Table 2.10) and appeared to be driven by a small but non-significant difference in FNPA scores in the videoconference sample (see Table 2.11).

Table 2.10. Comparisons of episodic memory tasks by study version (online sample only)

Episodic memory task	Study version	<i>M</i>	SD	<i>t</i> (df)	<i>p</i>	<i>d</i>
FNPA Del.	1	6.20	2.25	0.12 (19)	0.906	0.05
	2	6.09	1.92			
VPA Del.	1	4.80	3.73	0.58 (19)	0.568	0.25
	2	5.82	4.24			
Story Recall Del.	1	18.26	5.52	0.93 (27)	0.359	0.36
	2	16.30	5.08			
4MT	1	11.50	2.46	0.09 (19)	0.927	0.04
	2	11.36	4.03			

Table 2.11. Comparisons of episodic memory tasks by study version (videoconference sample only)

Episodic memory task	Study version	<i>M</i>	SD	<i>t</i> (df)	<i>p</i>	<i>d</i>
FNPA Del.	1	6.80	1.75	1.44 (17)	0.167	0.66
	2	5.56	2.01			
VPA Del.	1	7.70	3.47	0.60 (17)	0.550	0.28
	2	6.78	3.15			
Story Recall Del.	1	19.72	4.84	0.62 (15)	0.544	0.31
	2	18.44	3.49			
4MT	1	11.30	3.59	0.79 (17)	0.438	0.36
	2	10.00	3.54			

2.10.3 Comparisons of study modality

Independent samples *t*-tests were used to compare participants' performance on individual episodic memory and executive control tasks across study modalities (i.e., online/remote [A] versus videoconference [B]). Note that this sample was collapsed across study versions. Besides Verbal Fluency, there were no significant differences across study modalities on any of the tasks; however, the online/remote administration of VPA Delayed and Story Recall Delayed yielded slightly lower scores than the videoconference version of these tasks. Results are reported in Table 2.12.

Table 2.12. Comparisons of episodic memory tasks by study modality

Neuropsychological task	Study modality	<i>M</i>	SD	<i>t</i> (df)	<i>p</i>	<i>d</i>
FNPA Del.	A	6.15	2.03	0.11 (38)	0.915	0.03
	B	6.21	1.93			
VPA Del.	A	5.33	3.94	1.68 (38)	0.102	0.53
	B	7.26	3.26			
Story Recall Del.	A	17.59	5.37	1.01 (44)	0.318	0.31
	B	19.12	4.18			
4MT	A	11.43	3.30	0.69 (38)	0.494	0.22
	B	10.68	3.53			
Mental Control	A	24.85	5.77	0.66 (35)	0.511	0.22
	B	26.18	6.39			
Verbal Fluency	A	41.11	8.78	2.20 (35)	0.034	0.72
	B	34.10	10.43			
Backward Digit Span	A	7.15	2.82	0.84 (36)	0.404	0.27
	B	6.39	2.73			

2.10.4 Comparisons by participant sex

Independent samples *t*-tests were used to compare performance between male and female participants on the individual episodic memory tasks, collapsed across study versions and modalities. These analyses revealed no significant group differences.

2.10.5 Confirmatory factor analysis (CFA)

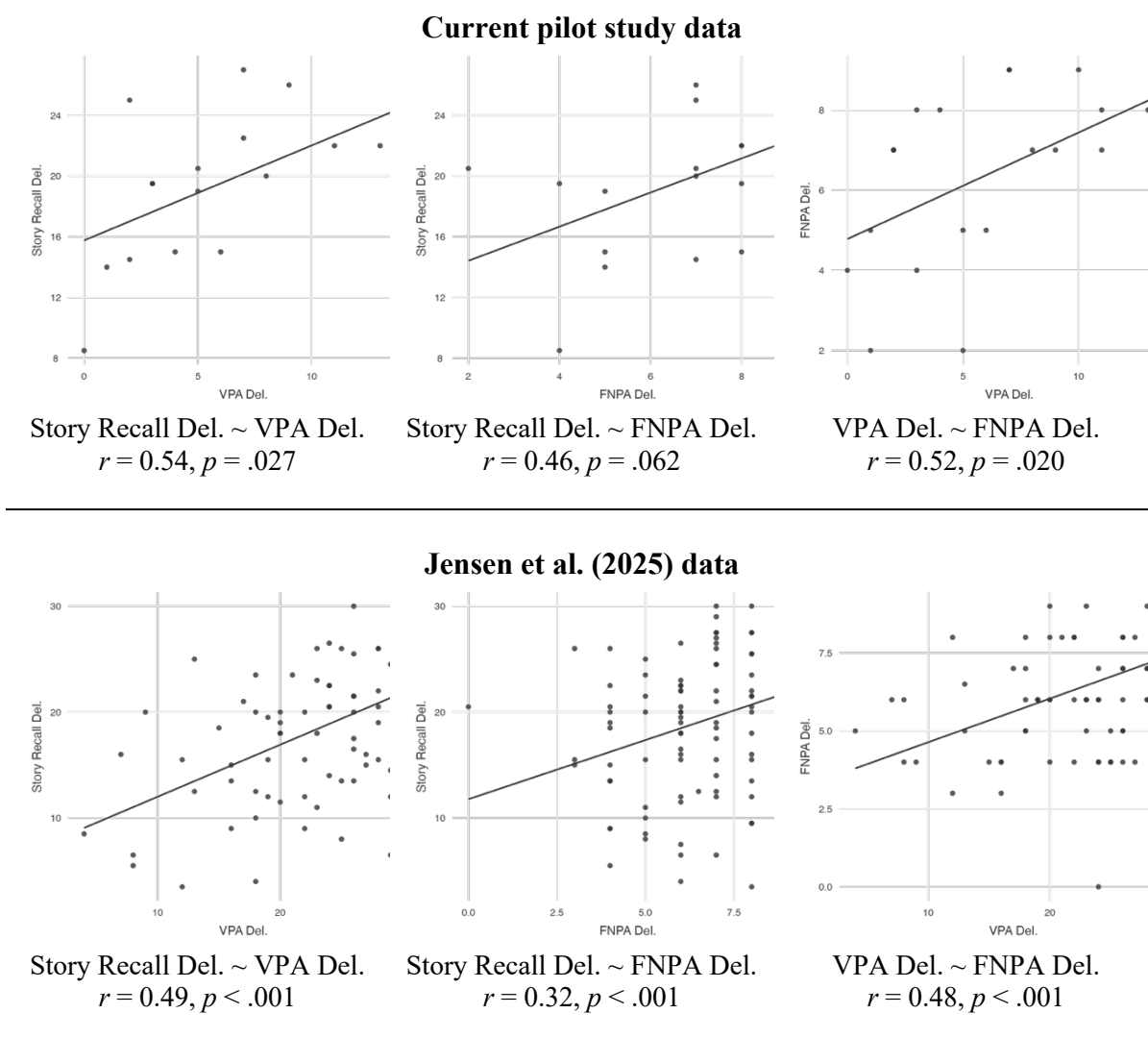
CFA was performed to evaluate the fit and factor structure of the updated episodic memory and executive control batteries using data from the young female participants from Jensen et al. (2025). In this context, using CFA allows us to see whether a relationship between our individual episodic memory and executive control measures and their underlying constructs exist in the present battery, which will help us understand how the updated episodic memory and executive control measures might fit together as separate factors in Study 3.

Because 4MT showed inconsistent correlations with the verbal tasks in the episodic memory battery (Jensen et al., 2025), this task was not included in the first set of analyses. Before performing the CFA, we first verified the patterns of associations among FNPA, VPA, and Story Recall in female participants only to qualitatively compare them to those from Jensen et al. (2025). As expected, the strength and direction of these correlations were comparable between the two datasets (see Figure 2.1).

The first CFA model was constructed as follows:

1. Episodic memory factor ~ FNPA Del. + VPA Del. + Story Recall Del.
2. Executive control factor ~ Mental Control + Verbal Fluency + Backward Digit Span

CFA results showed that the two-factor model had acceptable fit, with CFA and TLI $> .95$, SRMR $< .08$, and RMSEA $< .10$. All individual tasks loaded significantly onto their respective factors (all $p < .001$). Standardized factor loading estimates and fit statistics are reported in Table 2.13.

Figure 2.1. Scatterplots for verbal episodic memory tasks**Table 2.13.** CFA factor loadings and model fit statistics

	Factor	
	Episodic memory	Executive control
FNPA Del.	0.54***	
VPA Del.	0.67***	
Story Recall Del	0.67***	
Mental Control		0.80***
Verbal Fluency		0.41***
Backward Digit Span		0.57***
Model fit statistic		

CFI	0.96
TLI	0.93
RMSEA	0.07
SRMR	0.06

Note. 4MT = Four Mountains Task; CFI = comparative fit index; FNPA = Face-Name Paired Associates; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; TLI = Tucker-Lewis index; VPA = Verbal Paired Associates.

*** $p < .001$

A second CFA was performed on the two-factor battery, this time with the 4MT, to confirm whether this task should be included with the verbal ones in the episodic memory factor. The second CFA model was therefore constructed as follows:

1. Episodic memory factor ~ FNPA Del. + VPA Del. + Story Recall Del. + 4MT
2. Executive control factor ~ Mental Control + Verbal Fluency + Backward Digit Span

This second CFA showed comparable model fit to the previous one, although absolute fit indices CFI and TLI were slightly smaller. As expected, the 4MT did not load as strongly onto the episodic memory factor as the verbal tasks. Standardized factor loading estimates and fit statistics are reported in Table 2.14.

Table 2.14. CFA factor loadings and model fit statistics (with 4MT)

	Factor	
	Episodic memory	Executive control
FNPA Del.	0.55***	
VPA Del.	0.78***	
Story Recall Del	0.65***	
4MT	0.26*	
Mental Control		0.80***
Verbal Fluency		0.46***
Backward Digit Span		0.60***
Model fit statistic		

CFI	0.94
TLI	0.91
RMSEA	0.07
SRMR	0.06

Note. 4MT = Four Mountains Task; CFI = comparative fit index; FNPA = Face-Name Paired Associates; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; TLI = Tucker-Lewis index; VPA = Verbal Paired Associates.

* $p < .05$, *** $p < .001$

2.11 Discussion

The purpose of the present pilot study was to examine the suitability of a web-based, self-administered episodic memory and executive control battery from Jensen et al. (2025) for use in Study 3 of the present thesis. To this end, we modified the battery to be self-administered online and developed parallel forms of the episodic memory tasks for repeated testing in Study 3.

Preliminary results suggest that the updated, two-factor neuropsychological battery is suitable for remote use in Study 3, with the online study version yielding similar performance to its videoconference-based version. This is in line with many studies that validated neuropsychological batteries for remote use (e.g., Backx et al., 2020; Kochan et al., 2022; Uittenhove et al., 2023; for a review, see Belleville et al., 2023). Factor analysis results further suggested that the individual verbal episodic memory tasks and executive control tasks fit well as separate factors, although the 4MT did not load as strongly onto the episodic memory factor. This was expected, as the 4MT showed inconsistent relationships with the verbal memory tasks, both in the present analyses and in Jensen et al. (2025). In line with this, recent data also showed that the 4MT had weaker factor loading estimates than FNPA, VPA, and Story Recall on the episodic memory factor (Jensen et al., 2025). Taking these findings into account, in Study 3, we plan to exclude 4MT from the episodic memory composite and instead examine this task separately from the verbal ones. It should be noted that OC use appears to affect verbal episodic

memory more reliably than visuospatial memory (Gurvich et al., 2023); therefore, it seems reasonable to employ a composite consisting entirely of verbal tasks.

It is also worth noting that participant scores on Version 1 of Story Recall and VPA were slightly, but not significantly, higher than Version 2 of these tasks, suggesting that their parallel forms may differ somewhat in terms of difficulty. More important, however, is the distribution of the episodic memory composite scores: Due to the slightly higher Story Recall and VPA scores in Version 1, it is possible that this study version might yield slightly higher episodic memory composite scores. To account for this potential difference in Study 3, we will counterbalance the administration of study versions across participants and standardize individual memory scores based on the score distributions from Part 1 data to account for any version-based differences across timepoints.

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3. Chapter III – Effects of oral contraceptive initiation on objective and subjective episodic memory: Cross-sectional and longitudinal data (Study 3)

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Abstract

The invention of oral contraceptives (OC) transformed women's reproductive health over 60 years ago, but only recently has research on their possible influences on human cognition begun to emerge. OC use has previously been linked to verbal episodic memory. However, their effects remain unclear due to methodological inconsistencies and limitations across the literature, including the predominance of cross-sectional designs. The present research investigates the role of OC use in objective and subjective memory across two separate datasets. First, we provided a cross-sectional replication and extension of our previous research by comparing $n = 60$ OC users to $n = 75$ non-users. Second, we prospectively evaluated OC-related changes in memory following OC initiation in $n = 37$ new OC users (compared to $n = 43$ current OC users and $n = 45$ non-users) using a quasi-experimental, repeated-measures approach. Whereas the first analysis suggested slightly better objective memory among OC users compared to non-users, no such effects were observed after three months of OC use in the second analysis. A similar pattern occurred across datasets for memory satisfaction. Effects of OC hormones on memory may only emerge following longer exposure (i.e., more than 3 months). We discuss possible implications of our findings for the field of OC research and methodological considerations for future studies.

Keywords: oral contraceptives, memory, sex hormones, subjective memory, affect, mood

3.1 Introduction

Oral contraceptives (OC) were introduced more than 60 years ago and have since become one of the most widely used forms of contraception worldwide, with over 150 million users as of 2022 (United Nations, 2022). By altering the hormonal milieu, OCs have the potential to produce a range of physiological and psychological effects. Whereas early research primarily focused on the human body, a small but growing literature is now recognizing the possible interactions between OCs and the human brain (for reviews, see Brønnick et al., 2020; Heller et al., 2022; Lacasse et al., 2024; Montoya & Bos, 2017; Pletzer et al., 2023a; Pletzer & Kerschbaum, 2014).

Most combined OCs² contain ethinyl estradiol and one of several progestins, which are synthetic forms of estradiol and progesterone, the most abundant naturally occurring sex hormones in adult females. In both humans and animal models, estradiol and progesterone receptors are expressed across the brain and highly concentrated in regions linked to reproduction, such as the hypothalamus and pituitary gland (for reviews, see Almey et al., 2015; Azcoitia et al., 2011; Rossetti et al., 2016). They are also widely present in the hippocampus/MTL and PFC (Azcoitia et al., 2011; Almey et al., 2015; Brinton et al., 2008; Gonzalez et al., 2007; Wang et al., 2010). Via actions on these receptors, ovarian hormones exert neurotrophic effects which can alter behaviour (Azcoitia et al., 2011; Becker & Hu, 2008; Wang et al., 2010; for review, see Luine, 2014; Taxier et al., 2020).

Given the structural similarity to endogenous hormones, synthetic hormones contained in OCs can act on many of the same neural pathways (for reviews, see Lacasse et al., 2024; Petersen et al., 2023). For instance, by acting on the HPG axis, OCs suppress endogenous ovarian hormone function and inhibit ovulation (Sahlberg et al., 1987). Consequently, both the

² From this point forward, any use of the term “OC” refers to combined OC formulations containing both ethinyl estradiol and a progestin, unless otherwise specified.

suppression of endogenous hormone fluctuations and the presence of exogenous hormones may drive neural changes in OC users (Hampson, 2023). Indeed, OC use has been linked with alterations in brain structure, function, and connectivity across regions (Bottenhorn et al., 2025; Heller et al., 2022), including in the hippocampus and surrounding MTL (e.g., Noachtar et al., 2022; Lisofsky et al., 2016; Pletzer et al., 2015a, 2019a; Sharma et al., 2020b; for reviews, see Brønnick et al., 2020; Song et al., 2023; but see De Bondt et al., 2013; Petersen et al., 2015), a region that is unquestionably involved in episodic memory.

Despite this mounting neurobiological evidence, relatively little attention has been paid to the *cognitive* effects of OCs on memory³. Associations between OC use and performance have been reported across various cognitive domains, including verbal and visual episodic memory (i.e., one's long-term, explicit recollection of personally experienced events; Tulving, 1972), visuospatial ability, verbal abilities, and working memory (Gurvich et al., 2023; Kowalczyk et al., 2023; Warren et al., 2014). However, the associations are not always significant, the number of studies in humans remains surprisingly small, and these are limited by methodological inconsistencies (Beltz & Moser, 2020; Taylor et al., 2021; Warren et al., 2014).

A major concern is the predominance of cross-sectional studies. Although OC research has grown more rigorous over the past decade, most studies rely on the comparison of OC users versus non-users, without random assignment, increasing the chances of confounds and biases being introduced. Further, these studies have generally failed to account for the potential heterogeneity in OC formulations, duration of use, HC use history, and pill phase across participants, all of which may moderate the effects of OCs on cognition (Gurvich et al., 2023; Warren et al., 2014). Because these effects are likely subtle (e.g., Hochheim et al., 2025;

³ From this point forward, any use of the term “memory” refers to episodic memory, unless otherwise specified.

Peragine et al., 2020), most cross-sectional OC studies conducted to date have lacked the sensitivity to detect them while also considering potential confounding variables. One might think that a superior approach to studying the effects of OCs would lie in true experimental study designs such as RCTs (e.g., Gingnell et al., 2016; Petersen et al., 2021), but such designs often have prohibitively high costs and raise complex ethical considerations regarding the administration of placebos: Double blind placebo-controlled trials can also be less attractive to potential participants, who may be uncomfortable with receiving a placebo contraceptive. This may introduce a sampling bias, ultimately making study samples less representative of actual OC users, and leading to potential confounds such as the use of backup hormonal contraception (e.g., the morning-after pill). Fortunately, a compromise is available: Quasi-experimental designs, particularly those incorporating both between- and within-subjects comparisons (e.g., Lisofsky et al., 2016), present a more economical alternative to RCTs. At the same time, quasi-experimental designs offer significant advantages over cross-sectional ones, including the use of longitudinal data which permits one to establish a degree of temporal precedence between the independent and dependent variables, thus allowing for stronger causal inferences to be made.

With these considerations in mind, we sought to examine the effects of OC initiation on both verbal and visual episodic memory by implementing a pre-post, quasi-experimental design. We included both objective and subjective measures of memory.

3.1.1 Objective episodic memory

One of the most studied domains in OCs is episodic memory, which is not surprising given its strong links to the estrogen-receptor-rich hippocampal/MTL region. Some research on the cognitive effects of OC use has suggested a small enhancing effect on verbal memory. Yet, this effect is not consistent across all studies (Gurvich et al., 2023). Potential memory benefits

may depend on the hormonal profiles of both OC users and the individuals to whom they are compared. According to several studies, OC users perform similarly to naturally cycling women in high-hormone phases (e.g., midluteal; but see Lagunas et al., 2026) but show advantages when compared to those in low-hormone phases (e.g., early follicular; Gogos, 2013; Peragine et al., 2020; Hochheim et al., 2025). Similar benefits have also been observed during periods of elevated synthetic hormones, such as the active pill phase or shortly after pill ingestion, when levels of circulating hormones peak (Mordecai et al., 2008; Peragine et al., 2020).

Some studies have reported that differences between OC users and comparison groups emerge primarily in delayed recall of verbal materials, pointing to consolidation and/or retrieval processes as especially sensitive to hormonal modulation (Davignon et al., 2024; Gogos, 2013; Mordecai et al., 2008; Peragine et al., 2020; Plamberger et al., 2021; but see Hochheim et al., 2025; Plamberger et al., 2021). However, these findings are not universal, with several studies finding no significant differences between users and non-users, across pill phases, or as a function of progestin type (Islam et al., 2008; Jensen et al., 2023; Kuhlmann & Wolf, 2005; Mihalik et al., 2009; Gurvich et al., 2020).

Recently, we found that OC users performed slightly (but not significantly) better than naturally cycling participants on delayed story recall (Jensen et al., 2023; see also Peragine et al., 2020). However, that study's cross-sectional design and lack of control over OC-specific variables (e.g., pill formulation, pill phase, OC use history) and menstrual cycle phase of naturally cycling controls limited our conclusions. Taken together, these results highlight the need for a more systematic study to clarify whether these observed associations are reliable or whether they are context-dependent and limited by study design.

3.1.2 Subjective memory

Although objective laboratory-based neuropsychological tests of episodic memory are useful measures of memory functioning, they may be somewhat limited in their ecological validity and transferability to everyday memory abilities (Chaytor & Schmitter-Edgecombe, 2003; Isquith et al., 2013). That is, objective cognitive tests may fail to capture the subtle, subjective changes in memory that people perceive in their everyday environment (Bell et al., 2020; Isquith et al., 2013). Therefore, a valid and useful supplement to measuring objective memory is the assessment of subjective memory through self-report questionnaires (Bell et al., 2020).

People's perceptions of their memory may be associated with changes in their hormones. Most studies on this topic have focused on subjective memory complaints during or after the menopause (for a review, see Reuben et al., 2021) and on sex differences in subjective memory ratings (e.g., Csábi et al., 2023; Van der Werf & Vos, 2011; for a review, see Jonker et al., 2000). We are aware of only two direct examinations of the relationship between subjective memory and ovarian hormones—natural or synthetic—in young, premenopausal women, and these have yielded null findings. Ford et al. (2004) compared individuals in various hormonal stages (i.e., pre- vs. peri- vs. post-menopause) to those taking exogenous hormones, including OCs. They found no significant differences in subjective memory complaints across groups. Similarly, Hodgetts et al. (2015) found no significant associations between meta-memory and estradiol levels in a sample of cognitively normal, naturally cycling individuals.

3.1.3 The present research

To examine how OC use might influence objective and subjective memory, we conducted two pre-registered sets of analyses, with separate samples. Part 1—which aimed to avoid discarding single time point data from Part 2 (see Method)—is a replication and extension

of our previous cross-sectional comparison of OC users and naturally cycling individuals on memory measures (Jensen et al., 2023). Part 2 employed a quasi-experimental, repeated-measures design to examine objective and subjective memory in individuals assessed before and after initiating OC use with sample size determined *a priori* via power analysis.

To control for hormonal phase effects, in both parts we restricted OC users and naturally cycling participants to comparable low-hormone phases of their respective cycles (i.e., inactive pill phase and menses, respectively; as recommended by Beltz, 2022; see also Elliott-Sale et al., 2013). We further limited OC users to ethinyl estradiol-based combined formulations. In addition to memory, baseline executive control was also assessed (reported in Appendix B1) given prior evidence linking OC use to aspects of executive functioning (for a review, see Gurvich et al., 2023; but see Kowalczyk et al., 2023). Across both sets of analyses, we used composite scores of objective memory in primary analyses rather than single tests, to improve the estimation of neuropsychological constructs and increase statistical power.

In Part 1, we hypothesized that OC users would outperform naturally cycling participants on the objective memory composite. In Part 2, we expected current OC users to have higher memory scores than naturally cycling participants at Time 1. We also expected modest improvements in memory over time for all participants, with significantly larger increases among OC initiators (which would be reflected by a group-by-time interaction).

3.2 Method

3.2.1 *Participants*

Participants were recruited between September 2023 and September 2025 from the student research participation pool at a local university, social media (i.e., Reddit and Facebook posts), and the local community via study posters and word-of-mouth. Interested individuals

completed a pre-screening questionnaire to determine their eligibility. Eligible participants were female English speakers between the ages of 18 and 30 with normal or corrected-to-normal vision belonging to one of three groups: new OC users (newOC), current OC users (cOC), and naturally cycling individuals (NC). newOC were eligible if they were planning on starting a combined OC pill containing ethinyl estradiol in the following weeks or months and had not taken any form of HC within the previous 6 months. cOC were eligible if they had been taking the same form of ethinyl estradiol-based combined OCs for at least 6 months. NC participants must not have taken any form of HC within the previous 6 months.

Study exclusion criteria included previous hysterectomy or oophorectomy, current pregnancy, and current use of non-oral form HC (e.g., patch, intrauterine device, vaginal ring, injectable). To achieve a more representative sample, we did not exclude participants based on self-reported irregular menstrual cycle or mental health disorder; however, we did screen participants for depressive symptoms to control for these in our analyses if needed.

The final sample for Part 1 consisted of $N = 135$ participants: $n = 60$ cOC and $n = 75$ NC. The final sample for Part 2 consisted of $N = 125$ participants: $n = 37$ newOC, $n = 43$ cOC, and $n = 45$ NC. The sample size for Part 2 was determined *a priori* using *ANOVA_power* (https://shiny.ieis.tue.nl/anova_power/) to detect a small-to-medium effect ($\eta^2 = .05$; based on the smallest effect size of interest reported in previous studies; Gogos, 2013) at 80% power and $\alpha = .05$, for repeated-measures ANOVA with 3 groups and 2 measurements. The sample size for Part 1 was not determined via power analysis; rather, it consisted of all participants who completed the first testing session and were subsequently lost to attrition. A post hoc power analysis in G*Power suggested that our final Part 1 sample size of $N = 135$ would give us 64% power to detect a small-to-medium between-subjects effect. However, using composite

neuropsychological scores instead of single tests minimizes error variance, thus increasing statistical power (Davidson & Jensen, 2022; Jensen et al., 2025). This project was approved by the University of Ottawa Research Ethics Board (REB #H-11-22-8715)

3.2.2 Materials

Due to COVID-19, and to facilitate participant recruitment and retention, all study materials were administered remotely using Qualtrics and Gorilla Experiment Builder (www.gorilla.sc; Anwyl-Irvine et al., 2020). Previous studies have shown that the remote or computerized versions of our neuropsychological tasks are reliable and valid (Brearly et al., 2017; Brown et al., 2018; Cyr et al., 2021; Mahon et al., 2022).

3.2.2.1 Demographics, menstrual cycle, and OC use questionnaire

An initial questionnaire collected information about participants' age, years of education, gender identity, ethnicity, spoken language(s), and relationship status. cOC were asked to identify the brand name, duration, and hormonal formulation of their current OC prescription, their usual time of pill ingestion, whether the last pill they took was active or inactive, and the reason(s) for which they were taking OCs. newOC and NC were asked to report the start date of their last period, the expected start date of their next period, and the regularity of their menstrual cycle (i.e., almost always regular, more or less regular, or irregular). All participants were also asked to provide information about previous HC use, if applicable, including the type, duration, and age at initiation for each HC used.

3.2.2.2 Center for Epidemiological Studies Short Depression 10-item scale (CESD-10)

The CESD-10 (Andresen et al., 1994) measures symptoms of depression in the general population. Participants were presented with a list of 10 events (e.g., "I had trouble keeping my mind on what I was doing") and were asked to indicate on a 4-point Likert-type scale (1 = *rarely*

or none of the time to 4 = all of the time) the frequency with which they experienced each event in the past week. Total CESD-10 scores were calculated by summing all 10 items.

3.2.2.3 Positive and Negative Affect Schedule (PANAS)

The PANAS (Watson et al., 1988) is a self-report measure of positive and negative affect. Participants were presented with a list of 10 pleasant mood states (e.g., cheerful, relaxed, delighted) and 10 unpleasant mood states (e.g., sluggish, sad, guilty), and were asked to rate on a 5-point Likert-type (1 = *Very slightly or not at all* to 5 = *Extremely*) the extent to which they have experienced each mood state in the last week. Overall positive affect (PANAS-P) and negative affect (PANAS-N) scores were calculated by taking the average ratings for positive mood states and negative mood states, respectively.

3.2.2.4 Ten-Item Personality Inventory (TIPI)

The TIPI (Gosling et al., 2003) is a brief measure of the Big Five personality traits: extraversion, emotional stability (vs. neuroticism), conscientiousness, agreeableness, and openness. The scale contains 10 items with 2 measures per personality trait. Participants rated the extent to which each item applied to them using a 7-point Likert-type scale (1 = *Disagree strongly* to 7 = *Agree strongly*).

3.2.2.5 Multifactorial Memory Questionnaire (MMQ)

The MMQ is a self-report measure assessing three aspects of memory across separate scales: Contentment, Ability, and Strategies (Troyer & Rich, 2002). MMQ-Contentment includes 18 items inquiring about one's overall feelings toward one's memory (e.g., "My memory is really going downhill lately"). Participants rate their agreement on a 5-point Likert-type scale from 0 = *Strongly disagree* to 4 = *Strongly agree*. Total scores range from 0 to 72, with higher scores reflecting greater memory satisfaction.

MMQ-Ability features 20 items on common memory lapses or mistakes (e.g., “Not recall the name of someone you just met”), rated by how often they occurred over the past two weeks, from 0 = *All the time* to 4 = *Never*. Total scores range from 0-80, with higher scores indicating better memory ability.

MMQ-Strategies consists of 19 items relating to memory aids used in daily life, including 11 internal (e.g., “Mentally elaborate on something you want to remember”) and 8 external strategies (e.g., “Write things down in a calendar”). Participants report how frequently they used each strategy in the past two weeks, from 0 = *Never* to 4 = *All the time*. Total scores range from 0-76, with higher scores indicating more frequent strategy use. Subscales for internal and external strategies can be derived by summing designated items (Shaikh et al., 2021a).

3.2.2.6 Episodic memory battery

Many of the neuropsychological measures used in previous OC studies were initially developed for use in clinical contexts and were thus not sensitive enough to detect differences in cognition among healthy, young participants (as argued by Warren et al., 2014). Here, we employed an updated episodic memory battery derived from Glisky et al. (1995, 2001) initially constructed to reflect hippocampal/MTL-dominant processes. The present battery consisted of tasks that are sensitive to subtle differences in performance and have shown minimal ceiling effects in young adults (Jensen et al., 2023, 2025): Face-Name Paired Associates (FNPA; Caillaud et al., 2020), Verbal Paired Associates (VPA; Uttl et al., 2002), Story Recall (Taler et al., 2021), and the Four Mountains Task (4MT ;Chan et al., 2016).

A composite episodic memory score was constructed combining the delayed recall scores of FNPA, VPA, and Story Recall. Here, episodic memory was defined as the long-term, explicit recollection of personal events, including both the event and contextual details at the time of

retrieval (Tulving, 1972). Delayed recall, which relies particularly heavily on the hippocampus/MTL (Vargha-Khadem et al., 1997), reflects these key features. Accordingly, for the present composite episodic memory score, we prioritized the delayed recall features of the component tasks. Additionally, the delayed scores of each memory task were found to fit well together in previous factor analyses (Jensen et al., 2025). In that same study, 4MT did not load strongly onto the episodic memory factor; therefore, here we examined this task separately from the composite score.

Descriptions of the tasks included in the episodic memory battery can be found in [Section 2.9.2](#).

3.2.3 Procedure

Eligible participants were sent a calendar link to schedule their online testing session during their preferred time of day. To control for effects of menstrual cycle phase, cOC were asked to schedule their session during one of the inactive pill weeks of their cycle, whereas newOC and NC were asked to complete the study during menses. The study link was then sent to participants prior to their scheduled time slot. During this session, participants completed all questionnaires and neuropsychological tasks, including both the episodic memory and executive control batteries. The order of administration and parallel forms of the individual neuropsychological tests was counterbalanced across participants. The study lasted approximately 90 minutes, including a ten-minute break halfway through the session. Part 1 included data from cOC and NC who completed Time 1 but not Time 2. These participants were lost to attrition, but their Time 1 data were retained for Part 1 to avoid simply discarding these data.

Part 2 followed a within-between subjects, repeated-measures design. Participants underwent one testing session at baseline (Time 1; identical to the Part 1 participants) and another at follow-

up after 3 months (Time 2). The within-subject variables included all questionnaires, as well as the episodic memory composite scores (note that the executive control battery was not included at Time 2 because parallel forms of all component tasks could not be constructed). The between-subject variable was OC use status (newOC, cOC, and NC).

Following a 3-month delay⁴, participants who completed Time 1 were invited to schedule their second testing session (Time 2) at their preferred time of day. newOC and cOC scheduled their session during one of the inactive pill weeks of their cycle and NC scheduled it during menses. Participants then completed the questionnaires and parallel forms of the episodic memory battery once again. This second session lasted approximately one hour, and participants were offered a short break halfway through. The order of administration and parallel versions of the individual neuropsychological tests were counterbalanced across participants, to partially control for order effects and practice effects, respectively.

3.2.4 Data analysis

Part 1 – Cross-sectional analyses. First, distributions of certain demographic and OC-related variables (i.e., OC formulations, age, education years, language, OC use history, time of pill ingestion) were examined between participant groups to determine whether these should be included as covariates in our main analyses. Pearson correlations were used to examine relationships between individual memory and executive control tests. Regression-weighted standardized scores based on CFA were used to derive composite scores representing participants' relative episodic memory and executive control performance. Independent samples *t*-tests were used to compare groups on mood, personality, and MMQ scale scores, and analyses

⁴ In new OC users, circulating OC hormone levels may take up to three months (i.e., cycles) to stabilize (see Hampson, 2023). Additionally, individuals who experience negative side effects after starting a new pill prescription may be more likely to discontinue OCs within the first three months of use (Kulkarni, 2007; Kurshan & Epperson, 2006; Rosenberg & Waugh, 1998; Sanders et al., 2001; Westhoff et al., 2007).

of covariance (ANCOVA) were used for neuropsychological composites and 4MT scores.

Follow-up analyses were then performed to examine potential group differences on individual neuropsychological tests. Finally, Pearson correlations were used once more to explore relationships between OC use duration and cognitive measures.

Part 2 – Repeated-measures analyses. The distributions of certain demographic and OC-related variables (i.e., OC formulations, age, education years, language, OC use history, time of pill ingestion) were examined between participant groups to determine whether these should be included as covariates in our main analyses.

Repeated-measures analysis of variance (ANOVA) with Time (Time 1, Time 2) as the within-subjects factor and Group (newOC, cOC, NC) as the between-subjects factor was used to examine any main effects or group-by-time interaction effect of OC use initiation on episodic memory composites and subjective memory scores (MMQ). Following this primary analysis, additional repeated-measures ANOVAs were conducted to explore potential effects of Group, Time, or group-by-time on individual episodic memory measures and mood and personality questionnaire scores.

A significance level of .05 was used in all primary analyses and Holm-Bonferroni corrections were applied for secondary/exploratory analyses. All statistical analyses were preregistered (#261668, <https://aspredicted.org/gx87mz.pdf>) and performed using jamovi (Version 2.6; The jamovi project, 2025) and RStudio (Version 2025.5.1.513; Posit Team, 2025).

3.3 Part 1 results

3.3.1 Sample demographics and OC use characteristics

Sample demographics are reported in Table 3.1 and OC characteristics of cOC are reported in Table 3.2. Most cOC and NC participants reported English as their first language

(80% and 60%, respectively), although a χ^2 test of independence revealed that distributions of first language significantly differed between groups, $\chi^2(1) = 6.23, p < .05$ (critical value = 3.84), with the NC group consisting of more participants whose first language was not English.

Nearly half of cOC ($n = 17$) and six NC reported using HCs more than six months prior to the study, other than the OC currently prescribed to cOC. The mean start age of any form of HCs—which includes current OC used by cOC—was 16.0 years old ($SD = 1.87$) for cOC and 15.7 years old ($SD = 0.58$) for NC. The average duration of OC use among cOC was 3.1 years ($SD = 2.2$). The most common reasons for current OC use were to manage physical premenstrual symptoms, to prevent pregnancy, and to regulate irregular or missing menstrual cycles. Most cOC (33 of 60) were using combined OCs containing levonorgestrel.

Groups did not differ on CESD-10, $t(132) = 1.59, p = .113, d = .28$, PANAS-P, $t(133) = 1.45, p = .151, d = .25$, or PANAS-N, $t(133) = 1.22, p = .225, d = .21$. On the TIPI, cOC had significantly higher Openness scores, $t(133) = 2.04, p = .043, d = .35$, and marginally higher Conscientiousness scores than NC, $t(133) = 1.95, p = .053, d = .34$. Groups did not differ on Extroversion ($p = .184$), Agreeableness ($p = .934$), or Neuroticism ($p = .214$).

cOC had marginally higher MMQ-Contentment scores than NC, $t(124) = 1.94, p = .055, d = .35$. There were no group differences on MMQ-Ability, $t(124) = 0.32, p = .746, d = .06$, MMQ-Strategies, $t(124) = 0.53, p = .594, d = .09$, or either of the MMQ-Strategies subscales (Internal and External; see Table 3.1).

Table 3.1. Part 1 sample demographics

	cOC ($n = 60$)	NC ($n = 75$)
	M (SD) or N	
Age	19.80 (2.48)	19.60 (2.22)

Education (years)	13.78 (1.87)	13.77 (1.81)
Gender		
Woman	59	75
Non-binary	1	0
First language		
English	48	45
French	10	8
Other	2	22
Relationship status		
Single	28	51
Dating/in a casual relationship	8	9
In a serious relationship (but not engaged/married)	23	12
Engaged or married	1	3
Previous OC use (> 6 months prior)		
Yes	17	6
No	43	69
HC start age	15.59 (2.29)	15.67 (0.58)
OC duration (years)	3.02 (2.18)	-
Phase		
Inactive (cOC) / Menses (NC)	59	74
Reason(s) for OC use		
To manage physical premenstrual symptoms	33	-
To prevent pregnancy	30	-
To regulate irregular or missing menstrual cycles	26	-
To help treat acne or other skin problems	13	-
To help treat a condition such as endometriosis or PCOS	4	-
To help manage PMDD or other depressive symptoms	3	-
Other medication		
Yes	21	7
No	39	68
MMQ-Contentment*	44.54 (12.44)	39.55 (15.85)
MMQ-Ability	43.74 (16.23)	42.75 (17.51)
MMQ-Strategies	42.00 (11.60)	43.22 (13.59)

External Strategies	22.85 (5.50)	22.52 (6.35)
Internal Strategies	21.64 (8.75)	19.63 (7.77)
CESD-10	12.83 (5.38)	14.46 (6.24)
PANAS-Positive	28.12 (6.43)	26.35 (7.54)
PANAS-Negative	24.73 (8.37)	26.51 (8.43)
TIPI		
Extroversion	4.19 (0.71)	4.36 (0.74)
Agreeableness	4.73 (0.89)	4.72 (0.95)
Conscientiousness	4.32 (0.76)	4.05 (0.83)
Neuroticism	4.48 (0.76)	4.31 (0.86)
Openness*	4.32 (0.86)	3.99 (0.98)

Note. * $p < .05$. CESD-10 = Center of Epidemiological Studies Depression Scale - 10-item version; MMQ = Multifactorial Memory Questionnaire; PANAS = Positive and Negative Affect Schedule; TIPI = Ten-Item Personality Inventory.

Table 3.2. Part 1 and Part 2 OC user characteristics

Progestin generation	Progestin type	OC brand	Progestin (mg)	EE (µg)	Pill regimen # active (# inactive)	Part 1 cOC N	Part 2 newOC N	Part 2 cOC N
First	Norethindrone acetate	Lolo / Lo Loestrin Fe	1	10	24-2(2)	6	3	1
	Cyproterone acetate	Generic Taro-Cyproterone and EE	2	35	21(7)	0	0	1
Second	Levonorgestrel	Alesse (Alysena)	0.1	35	21(7)	28	19	19
		Aviane	0.1	20	21(7)	4	3	1
		Ovima	0.15	30	21(7)	1	0	0
		Marvelon (Mirvala)	0.15	30	21(7)	5	6	8
	Desogestrel	Freya	0.15	30	21(7)	2	0	4
Third	Norgestimate	Linessa	0.1-0.125-0.15	25	7-7-7(7)	2	0	0
		Tri-Jordyna	0.18-0.215-0.25	35	21(7)	2	1	0
		Tricira Lo	0.18-0.215-0.25	25	21(7)	0	1	3

Fourth	Drospirenone	Sprintec	0.25	35	21(7)	0	1	0
		Yaz	3	20	24(4)	6	1	4
		Yasmin	3	30	21(7)	0	1	0
		Mya	3	20	24(4)	3	0	2
		Generic Drospirenone and EE	3	20	24(4)	0	1	0

Note. EE = ethinyl estradiol; mg = milligram; µg = microgram.

3.3.2 CFA and creation of composite scores

Associations between individual tasks in the episodic memory and executive control batteries, respectively, were first examined using Pearson correlations. All correlations were significant and ranged from $r = .18$ to $.28$ for episodic memory (excluding 4MT) and $r = .11$ to $.38$ for executive control and were sufficiently large to justify running CFA.

A two-factor CFA using correlated-factor configuration was then used to examine the fit of the episodic memory battery (consisting of the delayed recall versions of VPA, FNPA, and Story recall) and executive control battery (see Appendix B1). Model fit was acceptable, with $\chi^2(8) = 4.84$, $p = .774$; CFI and TLI = 1.00; SRMR = .04, and RMSEA < .01 (Brown, 2006). All items loaded significantly onto their respective factors, with standardized factor loadings ranging from .36 to .71. CFA results, including standardized factor loadings and model fit indices, are reported in Table 3.3.

Finally, regression-weighted factor scores were calculated by converting scores for each individual neuropsychological task to z-scores (relative to the Part 1 sample's mean and standard deviation for each task version), multiplying z-scores by their item's respective regression weights (i.e., standardized estimates) and adding these together to form two composite scores representing relative episodic memory and executive control performance.

Table 3.3. CFA standardized factor loadings and model fit indices (Part 1)

	Factor 1 Episodic memory	Factor 2 Executive control
VPA Delayed	0.434	-
FNPA Delayed	0.418	-
Story Recall Delayed	0.652	-
Verbal Fluency	-	0.705
Mental Control	-	0.359
Backward Digit Span	-	0.546
Model fit		
	Chi-squared (df, <i>p</i>)	4.84 (8, .774)
	CFI	1.000
	TLI	1.000
	RMSEA (90% CI)	0.000 (0.00-0.07)
	SRMR	0.037

Note. CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; TLI = Tucker-Lewis index.

3.3.3 *Group comparisons on objective memory*

ANCOVAs were used to compare groups on the episodic memory composite and 4MT, controlling for first language spoken by participants (coded as 1 = English, 0 = other). Memory parallel task version was included as a between-subjects factor. cOC showed significantly higher memory composite scores than NC, $F(1, 122) = 4.86, p = .029, \eta^2 = .04$. There was also a significant interaction between group and task version, $F(1, 122) = 4.16, p = .044, \eta^2 = .03$. Following up on this interaction, we replicated the previous analysis using ANCOVAs, restricting the sample to one study version at a time. The group difference in memory was dependent on memory parallel task version, with only Version 1 showing a significant difference

between cOC and NC, $F(1, 58) = 7.25, p = .009, \eta^2 = .11$. This effect was not present on Version 2, $F(1, 63) = 0.08, p = .784, \eta^2 < .01$.

3.3.4 *Secondary analyses*

To follow up on our main research questions, we performed a series of secondary analyses, results for which are reported in Appendix B1. First, groups were compared on individual neuropsychological tasks using ANCOVAs once again (with first language as a covariate; see Table B1). cOC and NC did not significantly differ on any of these tasks, but the difference on VPA approached significance, with cOC performing marginally better than NC, $F(132) = 3.45, p = .066, \eta^2 = .03$. Once again, these effects were driven by task version: Restricting the sample to Version 1 yielded significant group differences with cOC outperforming NC on FNPA, $F(1, 63) = 7.20, p = .009, \eta^2 = .10$, and VPA, $F(1, 63) = 5.64, p = .021, \eta^2 = .08$, but not Story Recall, $F(1, 58) = 3.13, p = .082, \eta^2 = .05$, or 4MT, $F(1, 63) = 0.52, p = .473, \eta^2 < .01$. Restricting the sample to Version 2, on the other hand, revealed a lack of group differences across the board.

Second, Pearson correlations were used on cOC data exclusively to examine relations between duration of OC use and neuropsychological scores (see Table B2). None emerged as significant. Finally, because we had previously found associations between depression ratings and subjective memory ratings (Jensen et al., 2024), and to follow up on potential contributors to OC and subjective memory, Pearson correlations were also performed on CESD-10 and MMQ scores (combined and by group; see Table B3). In both groups, all MMQ scales—except for Internal Strategies in the cOC group—were moderately correlated with CESD-10 ratings. Specifically, CESD-10 scores shared inverse associations with MMQ-Contentment and MMQ-

Ability, and positive correlations with MMQ-Strategies and its subscales. Additional analyses are reported in Appendix B1.

3.4 Part 2 Results

3.4.1 *Sample demographics and OC use characteristics*

Sample demographics are reported in Table 3.4 and OC characteristics of newOC and cOC are reported in Table 3.2. Similar to Part 1, most participants indicated that their first language was English; however, a χ^2 test of independence showed that distributions of first language did not significantly differ between groups, $\chi^2 (2) = 3.83, p > .05$ (critical value = 5.99).

The mean interval between Time 1 and Time 2 was 87.6 days (SD = 15.6) for newOC, 90.1 days (SD = 16.2) for cOC, and 95.4 days (SD = 21.3) for NC. The average duration of OC use among newOC (measured at Time 2) was 2.93 months (SD = 1.13). The average duration of OC use among cOC (measured at Time 1) was 2.89 years (SD = 1.99). Approximately half of newOC ($n = 14$) had used some kind of HC more than six months prior to the study, as well as one third of cOC ($n = 11$), and less than a fifth of NC ($n = 6$). The mean start age of any form of HC was 18.05 years old (SD = 3.19) in newOC, 17.95 years old (SD = 2.56) in cOC, and 15.00 years old (SD = 2.83) in NC. Note that the mean age at which cOC started HCs was significantly higher in Part 2 than in Part 1, $t (57) = 3.31, p = .002, d = .95$.

Among both newOC and cOC, the most common reasons for starting OC were to prevent pregnancy and regulate irregular or missing menstrual cycles. Similar to Part 1, most newOC ($n = 22$) and cOC ($n = 20$) were using combined OCs containing levonorgestrel.

At Time 1, groups did not differ on CESD-10, $F (2, 122) = 1.74, p = .180, \eta^2 = .03$, PANAS-P, $F (2, 122) = 0.67, p = .514, \eta^2 = .01$, PANAS-N, $F (2, 122) = 1.05, p = .354, \eta^2 = .02$, or any of the TIPI sub-scores (all $p > .05$).

Table 3.4. Part 2 sample demographics

	newOC (n = 37)	cOC (n = 43)	NC (n = 45)
	M (SD) or N		
Age	22.89 (4.20)	21.42 (3.07)	20.09 (3.32)
Education (years)	16.38 (3.14)	15.09 (2.40)	14.18 (2.28)
Gender			
Woman	35	43	45
Non-binary	2	0	0
First language			
English	27	34	27
French	5	5	7
Other	6	4	11
Relationship status			
Single	10	14	30
Dating/in a casual relationship	9	7	5
In a serious relationship (but not engaged/married)	16	20	8
Engaged or married	2	2	2
Previous OC use (> 6 months prior)			
Yes	14	11	6
No	23	32	39
HC start age	18.05 (3.19)	17.95 (2.56)	15.00 (2.83)
Reason(s) for OC use*			
To manage physical premenstrual symptoms	13	6	-
To prevent pregnancy	23	19	-
To regulate irregular or missing menstrual cycles	18	15	-
To help treat acne or other skin problems	7	14	-
To help treat a condition such as endometriosis or PCOS	6	6	-
To help manage PMDD or other depressive symptoms	1	0	-
Other	0	1	-
Other medication	6	13	8
TIPI			

Extroversion	4.14 (0.69)	4.35 (0.53)	4.34 (0.74)
Agreeableness	4.57 (0.83)	4.83 (0.91)	4.87 (1.05)
Conscientiousness	4.22 (0.82)	4.07 (0.74)	4.07 (0.79)
Neuroticism	4.50 (0.72)	4.77 (0.76)	4.41 (0.80)
Openness	4.22 (0.93)	4.20 (0.89)	4.28 (0.89)

Note. *Measured at Time 1 for cOC and at Time 2 for newOC

3.4.2 *Group-by-time comparisons on subjective memory*

A series of within-between-subjects ANOVAs was used to examine group-by-time effects on all three MMQ scales (see Table 3.5), revealing significant increases in memory contentment, $F(2, 122) = 4.28, p = .041, \eta^2 < .01$, and self-rated abilities over time, $F(2, 122) = 5.29, p = .023, \eta^2 < .01$, but no between-subjects or interaction effects on either scale. There were no significant effects for MMQ-Satisfaction.

3.4.3 *Group-by-time comparisons on objective memory*

Episodic memory composite scores were derived using the same method and factor weights as in Part 1. A within-between-subjects ANOVA revealed a significant improvement in memory from Time 1 to Time 2, $F(1, 102) = 33.84, p < .001, \eta^2 = .07$, but no between-subjects effect, $F(2, 102) = 0.45, p = .642, \eta^2 < .01$, or group-by-time interaction, $F(2, 102) = 0.05, p = .948, \eta^2 < .01$ (see Table 3.5).⁵

As in Part 1, we replicated the above analysis, restricting the sample to one study version at a time. When the analysis was restricted to participants who completed Version 1 at Time 1 (and Version 2 at Time 2), there was a significant increase in memory scores over time, $F(1, 49) = 13.38, p < .001, \eta^2 = .05$, but no significant effect of Group, $F(2, 49) = 0.59, p = .557, \eta^2 = .02$, or group-by-time interaction, $F(2, 49) = 1.67, p = .200, \eta^2 = .01$.

⁵ A within-between-subjects ANOVA was conducted with an imputed dataset (i.e., multiple imputation used to replace missing individual episodic memory values which were missing completely at random). This yielded very similar results as the original analysis.

When the sample was restricted to participants who completed Version 2 at Time 1 (and Version 1 at Time 2), there was also an increase in memory scores from Time 1 to Time 2, $F(1, 50) = 23.83, p < .001, \eta^2 = .10$, but no significant effect of Group, $F(2, 50) = 0.07, p = .937, \eta^2 < .01$, or group-by-time interaction, $F(2, 50) = 2.23, p = .118, \eta^2 = .02$.

3.4.4 *Group-by-time comparisons on individual memory tasks*

A secondary analysis of the individual tasks in the episodic memory battery was conducted using a series of mixed ANOVAs with Holm-Bonferroni corrections (see Table 3.5). On FNPA, VPA, and Story Recall, there was a significant within-subjects effect of time, but no significant effect of group or group-by-time interaction. On the 4MT, cOC had significantly higher scores compared to newOC, $F(2, 122) = 3.95, p = .022, \eta^2 = .04$. However, there were no significant within-subjects or interaction effects on 4MT scores.

3.4.5 *Group-by-time comparisons on mood and affect*

A secondary analysis of group-by-time comparisons on CESD-10 and PANAS scores was conducted using a series of within-subjects ANOVAs with Holm-Bonferroni corrections (see Table 3.5). Our analysis revealed a slight increase in positive affect from Time 1 to Time 2 among newOC, who also had higher scores than both cOC and NC at Time 2, as shown by a significant group-by-time interaction, $F(2, 122) = 3.41, p = .036, \eta^2 = .01$. However, Holm-Bonferroni-corrected post hoc analyses were not significant. There were also no significant within- or between-subjects effects on PANAS-P, nor any significant within-subjects, between-subjects, or interaction effects on CESD-10 or PANAS-N scores.

Table 3.5. Group-by-time comparisons on memory tasks, subjective memory, and mood (Part 2)

	nOC (<i>n</i> = 38)			cOC (<i>n</i> = 43)			NC (<i>n</i> = 45)			Within-subjects			Between-subjects			Interaction		
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	Time 1	<i>F</i> (df)	<i>p</i>	η^2	<i>F</i> (df)	<i>p</i>	η^2	<i>F</i> (df)	<i>p</i>	η^2
Memory composite	0.44 (0.92)	1.16 (1.03)	0.38 (0.88)	0.89 (1.16)	0.31 (1.16)	0.89 (1.03)	0.31 (1.16)	0.89 (1.03)	33.84 (1, 102)	<.001	0.07	0.45 (2, 102)	0.642	<.01	0.05 (2, 102)	0.948	<.01	
FNPA Delayed	6.97 (1.94)	6.84 (2.04)	6.91 (1.84)	7.54 (1.47)	6.69 (2.17)	7.51 (1.60)	6.69 (2.17)	7.51 (1.60)	6.08 (1, 122)	0.015	0.01	0.41 (2, 122)	0.666	<.01	2.57 (2, 122)	0.080	0.01	
VPA Delayed	6.86 (3.87)	8.54 (4.44)	6.98 (4.01)	8.54 (3.67)	7.24 (4.09)	8.24 (3.82)	7.24 (4.09)	8.24 (3.82)	20.46 (1, 118)	<.001	0.04	0.02 (2, 118)	0.983	<.01	0.22 (2, 118)	0.802	<.01	
Story Recall Delayed	22.22 (4.33)	24.95 (5.18)	21.60 (5.41)	23.67 (6.62)	21.08 (5.65)	23.73 (6.26)	21.08 (5.65)	23.73 (6.26)	11.15 (1, 104)	0.001	0.03	0.91 (2, 104)	0.406	0.01	0.43 (2, 104)	0.651	<.01	
4MT	11.14 (2.79)	10.32 (3.51)	12.19 (2.48)	12.37 (2.62)	11.36 (3.18)	11.16 (3.11)	11.36 (3.18)	11.16 (3.11)	0.98 (1, 122)	0.324	<.01	3.95 (2, 122)	0.022	0.04	1.04 (2, 122)	0.356	<.01	
MMQ-Contentment	40.08 (14.93)	42.16 (13.03)	43.12 (14.10)	44.49 (12.96)	42.27 (15.67)	45.67 (14.14)	42.27 (15.67)	45.67 (14.14)	4.28 (1, 122)	0.041	<.01	0.61 (2, 122)	0.545	<.01	0.31 (2, 122)	0.735	<.01	
MMQ-Ability	45.19 (17.94)	48.24 (17.44)	49.56 (14.06)	52.86 (11.21)	46.09 (17.03)	48.71 (16.18)	46.09 (17.03)	48.71 (16.18)	5.29 (1, 122)	0.023	<.01	1.25 (2, 122)	0.290	0.02	0.02 (2, 122)	0.975	<.01	
MMQ-Strategies	40.24 (13.89)	40.14 (15.05)	38.09 (10.05)	38.53 (10.47)	39.51 (14.26)	37.60 (14.48)	39.51 (14.26)	37.60 (14.48)	0.25 (1, 122)	0.621	<.01	0.29 (2, 122)	0.745	<.01	0.48 (2, 122)	0.622	<.01	
CES-D-10	11.54 (5.17)	12.57 (5.58)	11.26 (5.07)	12.40 (5.32)	13.24 (5.84)	13.09 (5.30)	13.24 (5.84)	13.09 (5.30)	1.96 (1, 122)	0.164	<.01	1.03 (2, 122)	0.362	0.01	0.79 (2, 122)	0.457	<.01	
PANAS-Positive	27.70 (7.49)	29.08 (7.77)	28.67 (5.75)	26.30 (6.35)	27.13 (5.69)	25.13 (6.56)	27.13 (5.69)	25.13 (6.56)	2.53 (1, 122)	0.114	<.01	1.71 (2, 122)	0.185	0.02	3.41 (2, 122)	0.036	0.01	
PANAS-Negative	23.27 (7.31)	25.38 (7.14)	22.93 (6.51)	23.67 (7.83)	25.04 (8.06)	24.93 (8.41)	25.04 (8.06)	24.93 (8.41)	1.81 (1, 122)	0.181	<.01	0.73 (2, 122)	0.485	<.01	0.88 (2, 122)	0.419	<.01	

Note. Means and standard deviations (in brackets) are reported for each measure. 4MT = Four Mountains Test; CES-D-10 = Center for Epidemiological Studies Depression Scale (10-items); FNPA = Face-Name Paired Associates; MMQ = Multifactorial Memory Questionnaire; PANAS = Positive and Negative Affect Schedule; VPA = Verbal Paired Associates.

3.5 Discussion

Previous findings on the influence of OC use on episodic memory have been inconclusive due in part to methodological inconsistencies and the predominance of underpowered, cross-sectional studies. The present research examined relations between OC use, objective episodic memory, and subjective memory ratings across two complementary study designs. Part 1 was a cross-sectional replication and extension of Jensen et al. (2023), whereas Part 2 used a quasi-experimental, repeated-measures design to assess changes in objective and subjective memory following OC initiation. This quasi-experimental approach remains an underutilized method in the OC literature and offers a more rigorous alternative to cross-sectional studies while remaining more feasible than RCTs. Additional strengths of the present research include the preregistration of our primary analyses, sample size planning from *a priori* power analysis; preplanned restrictions on menstrual cycle phase, pill phase, OC formulations, and previous HC use (as recommended by Beltz, 2022); and the use of composite neuropsychological scores. Together, these decisions reduce measurement error, increase statistical power, and improve comparability across groups, thereby addressing limitations that are common in OC research.

3.5.1 *OC use and verbal episodic memory*

Part 1 showed slightly higher episodic memory composite scores among OC users compared to non-users, an effect that was small-to-medium in size (note that this was only evident for Version 1 of the memory tasks; see methodological considerations below). This finding is consistent with previous studies hinting at a slightly enhancing effect of OC use on verbal memory (for a review, see Gurvich et al., 2023), particularly for delayed recall (Davignon

et al., 2024; Gogos, 2013; Mordecai et al., 2008; Peragine et al., 2020; but see Hochheim et al., 2025; Jensen et al., 2023; Plamberger et al., 2021).

In contrast, Part 2 did not detect a significant effect of OC initiation on episodic memory over the three-month testing period. This study design was inspired by Lisofsky et al. (2016), who examined the effects of OC initiation on brain structure and function, and cognition. Interestingly, although Lisofsky et al. reported structural and functional neural changes after three months of OC use, they found no corresponding changes in memory.

One possible explanation for the disagreement between our two sets of findings comes from the duration of OC use. Whereas participants in Part 1 had been using the same OCs for nearly three years on average, OC initiators in Part 2 had only been on the pill for approximately three months. This raises the possibility that the effects of OC use on verbal memory may only emerge after longer exposure. Previous studies reporting significant OC-related differences in verbal memory have involved young adults using OCs for varying amounts of time—i.e., between several months and several years (Davignon et al., 2024; Gogos, 2013; Mordecai et al., 2008; Peragine et al., 2020). However, while some of these durations were similar to our Part 1, Davignon et al. (2024) had a considerably large range (i.e., 4 months to 20 years) and other studies did not report information on OC use duration (Hochheim et al., 2025; Plamberger et al., 2021), making it difficult to determine when OC effects might emerge following initiation. A similar gap is highlighted in preclinical research: Length of exposure to OC hormones in animal models has also varied across studies (for reviews, see Concas et al., 2022; Hilz, 2022; Lacasse et al., 2025), yet there have been few direct investigations of the effects of different treatment durations on behaviour and the brain (Nwakanma et al., 2021).

Consistent with previous research, we did not find meaningful correlations between OC use duration and verbal memory measures in young adults (Davignon et al., 2024; Gurvich et al., 2020; Jensen et al., 2023; Wharton et al., 2008). In young adult samples, such as here, this may simply be an issue of restricted range: The longest that any of our participants had been using OCs was 12 years. In contrast, retrospective studies with middle-aged and older adults have reported positive, duration-dependent relationships between lifetime OC exposure and various cognitive abilities (Egan & Gleason, 2012; Lindseth et al., 2023; for a review, see Gregory et al., 2023; but see Watts et al., 2025), including verbal memory, with longer exposure (i.e., more than 10 years) showing the strongest association (Karim et al., 2016). Longer OC use has also been linked to greater hippocampal volume in current and previous users (Pletzer et al., 2015a, 2019a).

It follows that memory effects may be more likely to emerge after more than three months of exposure to OCs, although it is difficult to identify a clear time frame from the existing literature. Additional longitudinal studies spanning several years and incorporating multiple follow-ups post-OC initiation are needed to pinpoint the window of emerging cognitive effects. Given that such effects are likely small in size, future studies should also recruit sufficiently large samples of OC initiators to ensure adequate statistical power.

3.5.2 OC use and subjective memory

In Part 1, OC users reported marginally higher satisfaction with their everyday memory abilities than naturally cycling participants. However, this finding was contradicted by the lack of subjective memory effects following three months of OC use from Part 2, suggesting that OC initiators may not perceive differences in their own memory after such a short period of time. Previous studies investigating sex, gender, or hormonal influences on subjective memory have

also found conflicting results (e.g., Ford et al., 2004; Hodgetts et al., 2015; Csábi et al., 2023; Van der Werf & Vos, 2011; for a review, see Jonker et al., 2000).

Moreover, if subjective and objective memory effects were to emerge following OC initiation, these would not necessarily be closely related to each other (Van Patten et al., 2025). In fact, subjective memory ratings are more likely to be associated with mood and emotional states than with objective cognition (Van Patten et al., 2025). In line with this, in Part 2 we observed significant associations between depressive ratings on the CESD-10 and subjective memory. These findings suggested that individuals with higher depressive ratings were less satisfied with their memory, reported worse memory ability, and used more strategies, echoing previous findings (Chin et al., 2014; Csábi et al., 2023; Fort et al., 2004), including our own (Jensen et al., 2025).

3.5.3 Mood and personality

In line with our previous study (Jensen et al., 2023), no clear associations were found between OC use and low mood. The relationship between OC use and mood is complex and may vary across individuals. Previous studies have reported both beneficial and adverse mood effects linked to OC use (for reviews, see Hampson, 2023; Kraft et al., 2024; Lacasse et al., 2024), with several moderating factors believed to be at play including history of depression, prior OC-related mood experiences, age at OC initiation, and choice of contraceptive (for reviews, see Robakis et al., 2019; Roe et al., 2020; Schaffir et al., 2016). Personality factors have also been brought up as a potential explanation for cognitive differences between OC users and non-users, possibly influencing people's choice of contraceptive (Pletzer et al., 2022). However, a high-powered study found no significant personality differences between OC users and non-users (Beltz et al., 2019).

3.5.4 *Methodological considerations and study limitations*

Several methodological considerations should be acknowledged when interpreting our findings. First, our remote cognitive testing increased the accessibility of our study, allowing us to recruit a larger and theoretically more diverse sample than would have been possible with lab-based testing. Although this limited direct contact with participants and control over their engagement during the study, these potential limitations were mitigated by the inclusion of attention checks and use of cognitive tasks with reliable remote/computerized implementations (see Jensen et al., 2025). Part 1 also replicated findings from our videoconference-based study (Jensen et al., 2023), further supporting the feasibility of our remote battery.

Second, to allow for repeated testing, parallel versions of the memory tasks were used. Unexpectedly, both sets of analyses showed a significant effect of task version. Our results should therefore be interpreted with caution and replicated in independent samples using highly similar parallel task forms. Additionally, as argued by Plamberger et al. (2021), study designs using a longer delay between memory encoding and retrieval—possibly involving overnight memory consolidation—may also be important for capturing OC- and sex hormone-related memory effects.

Third, as there currently exist several dozen OC formulations varying in hormone dosage, progestin type, and phasic regimens, variability across OC formulations in our sample may have contributed to potential variance in our findings. To address this, we pre-emptively restricted OC users to ethinyl estradiol-based combined pill formulations, thereby forming more homogeneous groups than in many previous studies (for a review, see Gurvich et al., 2023). However, we did not impose any further restrictions on OC type; consequently, there remained variation in our sample in terms of hormone dosage and progestin class (as shown in Table 2). Progestins differ

in their hormonal profiles and affinities for androgen and estrogen receptors, producing varying effects in the CNS and cognition (for a review, see Pletzer et al., 2023b). Previous research has reported associations between progestin androgenicity and aspects of cognition such as visuospatial ability (e.g., Peragine et al., 2020; Wharton et al., 2008), verbal fluency (Griksiene & Ruksenas, 2011), and executive control (Gurvich et al., 2020; Wharton et al., 2008). Evidence for effects on verbal memory, on the other hand, is limited (Gogos, 2013; Gurvich et al., 2020; Jensen et al., 2023; Wharton et al., 2008), and no such associations with progestin class emerged from our data.

We also attempted to control for intra- and inter-individual hormonal variability by restricting the time of testing to the low-hormone phases of participants' respective cycles (as recommended by Beltz, 2022), as most combined OCs reduce endogenous estradiol and progesterone to early follicular phase (i.e., menses) levels—even during the inactive pill week—when these hormones are at their lowest (Elliott-Sale et al., 2013; Sahlberg et al., 1987). This approach allowed us to exert some level of control over individual differences in hormonal milieus and assured us that any significant findings were not merely attributed to group differences in pill or menstrual cycle phase. However, remote testing prevented us from collecting objective hormone measurements, so we were unable to verify participants' current pill and menstrual cycle phases and assess or control for differences in the hormonal milieus of those who were previously exposed to exogenous hormones.

Finally, the age at which participants initiated HC use varied across study samples. Emerging research suggests that earlier OC initiation—particularly during adolescence, when the brain is still developing—may be associated with distinct neural and psychological outcomes (reviewed by Lacasse et al., 2024). For example, OC use during adolescence has been linked to

altered neural activity during working memory tasks (Sharma et al., 2020b), although potential effects on episodic memory have not yet been found. Because our sample size did not allow us to control for age of HC initiation, future research should examine the effects of age at initiation more closely.

3.5.5 Considerations for future research

A major strength of the present research was its use of a prospective, pre-post design to examine memory changes in OC initiators. Few published studies have adopted such a quasi-experimental approach (Lisofsky et al., 2016), yet these designs are essential for understanding the course and timing of potential OC effects. There are several practical challenges associated with running quasi-experimental studies. One major consideration is the recruitment of adult OC initiators, who are becoming increasingly difficult to find. Fewer people today are choosing OCs, with many opting instead for longer acting and more convenient options such as the IUD (United Nations, 2022). This may be due in part to concerns about negative side effects of the pill and issues with daily compliance (Cooper & Patel, 2025; Frye, 2006; Lindh et al., 2016; Westhoff et al., 2007). Relatedly, researchers should also be aware of the selection and survivor biases that are inherent to OC research, with the OC-using population being self-selected to begin with, and then more likely to consist of individuals with no underlying health problems or who have not experienced significant side effects of the pill within the first few months of use (Rekers et al., 1996; Westhoff et al., 2007).

A related challenge is participant attrition. In the present study, 39% of participants (i.e., 108 of 280) across all groups were lost after Time 1 (subsequently, their baseline data were used for Part 1 of the study). Tracking participants over longer time intervals (i.e., several years) may prove even more difficult, especially if OC initiators discontinue or change their prescription

during the course of the study. Expecting a similar attrition rate, future longitudinal studies may require very large initial sample sizes (i.e., several hundred participants) to maintain sufficient statistical power.

Beyond these methodological concerns, our findings highlight an important question previously raised in the literature regarding the specific hormonal mechanisms underlying OC-related effects on verbal episodic memory and processing. OC use involves a complex interplay between endogenous and exogenous hormones, making it difficult to dissociate the respective neural and cognitive effects of suppressed endogenous hormones and the presence of their synthetic alternatives in the CNS (Hampson, 2020; Taylor et al., 2021). Addressing these questions will require more sophisticated longitudinal designs including precise hormonal measurements to capture hormonal changes over time, such as dense sampling approaches (Heller et al., 2025; Taylor et al., 2020; Zsido et al., 2023). Other biological variables previously found to interact with OC hormones such as stress/cortisol levels (Herrera et al., 2020; Sharma et al., 2020b; for a review, see Jentsch et al., 2022) and neurotransmitter genotypes (Gravelsins et al., 2021) should also be considered.

Future research in this field should also aim to study more diverse groups of people to gain a more representative picture of OCs. Most research thus far, including ours, has focused primarily on young, educated women in Western(ized) countries, yet effects may look somewhat different depending on individual-level factors such as age, reproductive history, gender roles and identity, socioeconomic status, and region (e.g., Beltz & Moser, 2020; Karim et al., 2016; Lyons et al., 2019; Pletzer et al., 2019b; Reynolds & Charlton, 2021). For example, OC formulations commonly prescribed in North America may not be the same in other parts of the world and, in turn, so might their effects on the brain and cognition (discussed in Beltz, 2024).

Finally, although OC-focused research remains important given the historical implications and widespread use of the pill, the field is expanding to other forms of HCs with distinct hormonal mechanisms, such as the IUD, which has recently become the most widely used form of hormonal contraception worldwide (United Nations, 2022). The typical hormonal IUD and the typical combined OC differ drastically in their length of hormonal exposure, route of administration, and localized effects. Additionally, whereas combined OCs contain varying levels of both EE and a progestin, IUDs only contain progestin and release it at a constant rate. Such notable differences between these two contraceptive methods may contribute to variations in their respective cognitive and behavioural effects (Beltz 2022). Integrating research across different contraceptive methods, regions, and populations will contribute to a better collective understanding of how HCs may influence women's brain health and cognition.

3.6 Acknowledgements

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3.7 Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request

3.8 Declaration of interest statement

The authors have no conflicts of interest to report.

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4. Chapter IV – General Discussion

4.1 Summary of results

Introduced more than 60 years ago, OCs are among the most widely used forms of hormonal contraception today (United Nations, 2022), yet their implications for human cognition remain poorly understood. Existing work has been limited by methodological inconsistencies including a reliance on cross-sectional designs, inadequate consideration of OC-related factors (e.g., formulation, previous HC use, duration of use), and variability in the tasks used to assess cognition. Episodic memory has emerged as a domain of interest, with some evidence suggesting small benefits of OC use, although findings remain mixed and inconclusive. Additionally, little research has focused on subjective perceptions of memory, which are important for understanding how OCs may influence everyday memory functioning and well-being.

Across three studies, the present thesis examined whether OC use is associated with objective and subjective memory while addressing several methodological gaps. The first two studies, which make up Chapter II, evaluated the psychometric properties and feasibility of the neuropsychological tools used in Study 3. Study 1 showed that the MMQ can be used with young adults, despite somewhat stronger reliability in older populations. Study 2 further supported the feasibility of a remotely administered, web-based episodic memory battery with parallel versions for repeated testing, while also indicating that the parallel forms may require additional validation. Building on this methodological foundation, Study 3 (Chapter III) examined associations between OC use and episodic memory using both cross-sectional and quasi-experimental approaches. Cross-sectional analyses suggested that longer-term OC use may be associated with slightly higher objective memory and ratings of memory satisfaction, whereas

longitudinal analyses indicated no significant changes in either domain after approximately three cycles of OC use.

Throughout the following section, I discuss the potential implications of the present thesis findings as well as additional considerations that may shed light on our results. I begin with OC-related factors that may help explain differences between our cross-sectional and longitudinal findings, then discuss potential confounds, subjective memory, executive control, key limitations, and future directions for the rapidly evolving field of OC research.

4.2 OC associations with objective episodic memory

In Study 3, differences between the cross-sectional and longitudinal findings were argued, in part, to reflect differences in OC use duration across the two samples. Specifically, we suggested that OC-related changes in verbal episodic memory may be more likely to emerge following prolonged exposure to OC hormones. Although this explanation remains plausible, other OC-related factors may have also contributed to our findings, including previous exposure to HCs and timing of initiation, OC formulation, and differences in ER affinities.

4.2.1 Considering previous HC use and timing of initiation

Previous HC exposure and timing of initiation may be particularly relevant to the absence of memory changes observed among new OC users in Part 2. Although study eligibility criteria required that participants had not used HCs within 6 months preceding the study, just over one third of new OC users ($n = 14$ out of 38) had used HCs earlier in life, 13 of whom had initiated them during adolescence (i.e., between 10 and 19 years of age; World Health Organization, 2019). This is also when close to one third of girls begin using HCs in Western society (Abma & Martinez, 2023; Ehrlich et al., 2011; Skovlund et al., 2016). Differences in age at initiation across the two study samples may also have contributed to differences between our cross-

sectional and longitudinal memory findings: Whereas Part 1 participants had initiated HCs at approximately 16 years of age, those in Part 2 had initiated them closer to 18 years of age, on average. These are important considerations because adolescence is a sensitive developmental period during which HPG axis activation and exposure to endogenous sex hormones contribute to brain reorganizing (Cahill, 2018; Schulz & Sisk, 2016). Several regions and functional networks undergo substantial development during this time (for a review, see Blakemore, 2012). Given the adolescent brain's heightened sensitivity to hormonal changes, it has been argued that the suppression of endogenous hormones through HC use during this period may have notable and potentially long-lasting effects on the brain and behaviour (Brønnick et al., 2020; Cahill, 2018).

One cognitive domain likely influenced by adolescent-onset HC use is episodic memory. Episodic memory processes rely on both the hippocampus and PFC, with the latter playing an important role in coordinating aspects of memory encoding and retrieval (Blumenfeld & Ranganath, 2007; Preston & Eichenbaum, 2013). Whereas the hippocampus usually completes much of its development by early adolescence (Gogtay et al., 2006), the PFC continues maturing throughout adolescence and into early adulthood (Lenroot & Giedd, 2006). HC initiation during adolescence may therefore influence the neural circuitry supporting memory, particularly through effects on prefrontal regions involved in memory-related cognitive control. Accordingly, studies have linked adolescent-onset OC use with structural and functional differences in memory- and executive control-related regions and circuits in adulthood (Heller et al., 2025; Mareckova et al., 2014; Sharma et al., 2020ab). Previous OC use has also been linked to larger grey matter volumes in the hippocampus of individuals no longer using the pill, although this relationship depended on time since discontinuation, suggesting that some OC effects on brain

structure may be reversible (Pletzer et al., 2019a). In terms of cognitive outcomes, previous HC use has been associated with better episodic memory and executive control in middle-aged and older women (Egan & Gleason, 2012; Karim et al., 2016; Watts et al., 2025).

It follows that HC use may have long-lasting neural and cognitive effects that depend on factors such as time at initiation, duration of use, and time since discontinuation (as argued by Cahill, 2018; Anderl et al., 2022; Egan & Gleason, 2012; but see Watts et al., 2025). Given these findings, previous HC exposure and age at initiation may have confounded the potential effects of OC use on memory in Study 3. However, we could not examine these associations due to limited statistical power. Future experimental and longitudinal studies examining OC initiation in adolescents or first-time adult users are therefore needed to control for previous HC exposure and to clarify its long-term impacts on episodic memory and its neural correlates.

4.2.2 OC formulation

OC formulation may have also played a role in Study 3 findings. Although we attempted to reduce heterogeneity related to OC-related factors by restricting OC users to EE-based combined formulations and testing them during the inactive pill phase, there remained some variability in hormone dosage and progestin class. Such differences in the pharmacological properties of OCs may have contributed to variability in memory performance. This may be particularly relevant for the 4MT, which was analyzed separately from the episodic memory composite and may engage visuospatial abilities that appear sensitive to differences in the hormonal properties of OCs, such as mental rotation. For example, androgenic progestins have been linked to better performance on visuospatial tasks in some studies (Gurvich et al., 2020; Peragine et al., 2020; Wharton et al., 2008) whereas higher estrogenic potency and higher EE doses have been associated with poorer mental rotation performance (Beltz et al., 2015; Hampson et al., 2022).

Preclinical findings also suggest that EE-related effects on spatial memory may be dose-dependent, with higher doses impairing performance and lower doses, which characterize most OCs prescribed today, having little to no effect (Mennenga et al., 2015). In this context, the marginally higher 4MT scores observed among OC users in Study 3 may partly reflect differences in OC subtype and overall estrogenic potency rather than OC use in general.

In contrast, verbal learning and memory show a consistent female advantage linked to estradiol (see [Section 1.1.4](#)), whereas associations with progesterone are mixed (Barros et al., 2015). Similarly, limited evidence suggests that OC-related effects on verbal memory may be more strongly related to estrogenic rather than androgenic mechanisms (Gogos, 2013; Gurvich et al., 2020; Jensen et al., 2023; Wharton et al., 2008). Heterogeneity in OC hormonal activity that was unaccounted for in our samples may have therefore blunted potential episodic memory effects in Study 3. Further research is needed to systematically examine the effects of different OC subtypes on cognition while also accounting for duration of use, timing of initiation, pill regimen, and reproductive history.

4.2.3 OC hormone affinity for ERs in CNS

Another factor to consider is the affinity of OC hormones for different ER subtypes. Estrogen acts through two main nuclear receptors, ER α and ER β . Although both receptor types are expressed in the brain, ER β expression appears to be more abundant in the hippocampus and may be more relevant than ER α to memory-related processes (see [Section 1.1.2](#)). Compared with endogenous estradiol, synthetic EE may have greater affinity for ER α and reduced affinity for ER β (Escande et al., 2006; Jeyakumar et al., 2011; see also Hampson, 2023). Because ER β is more highly expressed in the brain than ER α , this difference could mean that EE does not fully mimic the effects of endogenous estradiol in the CNS. As a result, OC-related effects on the

brain and cognition may vary depending on which ER-mediated pathways are most involved. In Study 3, differences in EE affinity for ER α and ER β may have influenced the extent to which OC use was associated with verbal episodic memory and other cognitive outcomes. However, the specific implications of these receptor-level differences remain poorly understood (Hampson, 2023).

Given the difficulty of conducting systematic longitudinal research with humans, questions related to OC interactions with ERs, duration and timing of OC use, previous hormone exposure, and OC formulation/dosage may be best addressed using preclinical models (e.g., Koebele et al., 2022; Lacasse et al., 2022; Tronson & Schuh, 2022; Gilfarb et al., 2025; Mennenga et al., 2015). Animal studies allow for greater experimental control over OC-related variables while also enabling the direct investigation of ER expression and receptor affinity. The field would therefore benefit from more dedicated preclinical research clarifying how OCs may influence cognition and behaviour, particularly through the use of comparable neurobehavioural paradigms to study memory.

4.2.4 Additional confounds: Task version and language background

Two additional factors may have influenced Study 3's results and therefore warrant further discussion: task version and participants' language background. First, our analyses revealed a significant group-by-version interaction in Part 1, with Version 1 producing larger group differences on the episodic memory composite. This finding was not entirely unexpected. In Study 2, Version 1 of Story Recall and VPA produced marginally higher scores than Version 2, suggesting that the parallel forms may differ slightly in terms of difficulty. To minimize the impact of these differences, in Study 3 we counterbalanced the administration of our battery across versions and standardized individual memory scores across versions, samples, and time

points. Nonetheless, the version effect observed in Study 3 was larger than anticipated based on the pilot study data. One possible explanation is that the relatively small sample size in Study 2 limited our ability to detect subtle version-related differences, leading us to underestimate their magnitude. Moreover, because Study 2 was designed to pilot our battery rather than to examine OC-related effects, we were not able to capture the ways in which task version and OC status might interact to influence memory. Consequently, the version effect observed in Study 3 may reflect both differences in task difficulty and individual variability related to OC use.

Importantly, the version effect does not necessarily discount the possible association between OC use and episodic memory. Although the group difference on episodic memory was larger for Version 1, this effect was in the same direction for Version 2. This suggests that the association between OC use and memory was not solely driven by version, but rather task version influenced the magnitude of the effect. These findings highlight the need to further validate our episodic memory measures for repeated administration. Future research should examine the psychometric properties of our memory tasks more closely, including item-level analyses, split-half reliability, and test-retest reliability. Researchers should also consider alternative approaches to counterbalancing, such as combining different task versions across testing sessions instead of administering one version uniformly at each time point. Finally, given the variability in the episodic memory tests used across OC studies, a meta-analysis would be useful for assessing the overall magnitude of OC-related effects on verbal episodic memory irrespective of task type and assessment method (discussed below).

Second, differences in participants' language background may also have acted as a confound in Study 3. Approximately one third of our samples consisted of non-native English speakers, and because the distribution of first language differed significantly across groups in Part 1, we

controlled for this in those analyses. Exploratory analyses further suggested no significant relationship between native language and most cognitive measures. One exception was Mental Control, which showed a significant language-by-group interaction, with higher scores among native English speakers than non-native speakers. This finding raises the possibility that other dimensions of language may have contributed additional variance to our results. Beyond asking participants when they acquired English, however, we did not assess other potentially relevant language-related factors, such as English proficiency and bilingualism, for example. Research on bilingualism and second-language acquisition suggests a complex relationship between language background and episodic memory, influenced by factors at the cognitive, task, and linguistic levels, including but not limited to executive control capacity, type of information recalled (e.g., words vs. images), age of language acquisition, and language usage and experience (e.g., Jeryous Fares & Taler, 2026; Schroeder & Marian, 2012). Perhaps most relevant to the present thesis is that language-related memory differences appear most likely to emerge on tasks that place substantial demands on semantic processing and language comprehension, such as verbal memory measures. Given that OC-related effects have been reported on verbal memory and verbal abilities (Beltz, 2022; Gurvich et al., 2023), language may remain an important yet overlooked variable in studies examining OC use and cognition. Future research should therefore account for participants' language background, proficiency, and other related factors when examining these relationships.

4.3 OC associations with subjective memory

To the best of my knowledge, Study 3 was the first study to examine OC use in relation to subjective memory, and one of the few studies to focus on the hormonal correlates of subjective memory in young adults (see [Section 1.3.4](#)). Cross-sectional analyses pointed toward

a small advantage on memory satisfaction among OC users but no significant differences in perceived memory ability or strategy use. Longitudinal analyses, however, indicated no significant effect of OC initiation on any measured dimensions of subjective memory. These findings suggest that, if anything, established OC users may be somewhat more content with their overall memory, but do not necessarily perceive themselves as making fewer mistakes or using more strategies to remember things in everyday life.

Although it is too early to draw any conclusions about our findings, one possible explanation for the apparent association between OC use and subjective memory may involve estrogen-related mechanisms. For instance, research on subjective memory complaints among perimenopausal and postmenopausal women points to a possible role of estrogen in perceived memory functioning (see [Section 1.3.4](#)). Another possibly related explanation is that OC use is linked to memory satisfaction through emotional mechanisms, as shown by significant correlations between MMQ scores and participants' mood ratings both here and in previous studies (Chin et al., 2014; Csábi et al., 2023, 2025; Fort et al., 2004; Jensen et al., 2025). As mentioned earlier, young adults' subjective memory may be more strongly associated with emotional factors than with objective memory performance (Csábi et al., 2025; Van Patten et al., 2025), which our present data also corroborate.

Nonetheless, although subjective and objective memory may not be directly related, there may be some overlap in terms of the hormonal mechanisms underlying each domain, including potentially beneficial effects of estrogen and OC use. More research will be needed to examine the extent of these relationships. Importantly, continuing to include both objective and subjective memory measures in future studies will allow researchers to differentiate OC-related effects attributed to perceived memory difficulties and those related to actual performance. Future

research building on our findings should also consider the limitations of using the MMQ with young adults. Although previous studies, including our own Study 1, supported its use with this population to a certain extent, the scale was originally designed for older adults and, as a result, some items may be less sensitive to memory issues and strategies affecting younger people. We therefore recommend that these findings be replicated using a modified version of the MMQ or different subjective memory questionnaires altogether (see [Section 2.4.1](#)).

4.4 OC associations with executive control

Although episodic memory was the central focus of the present thesis, executive control was also assessed at baseline in Study 3 to provide additional context for interpreting our memory-related findings, given the involvement of prefrontal-related processes in episodic encoding, retention, and retrieval processes (Blumenfeld & Ranganath, 2007; Preston & Eichenbaum, 2013). That said, OC use was not expected to have a strong effect on executive control, given null associations found in our previous study (Jensen et al., 2023) and in the OC literature more generally (see [Section 1.2.3.2](#)). Indeed, we did not find any significant group differences on executive control composites in Study 3. At the individual task-level, however, OC use duration showed a small positive association with verbal fluency that approached significance, shedding light on the mixed findings in the literature (see [Section 1.2.3.2](#)). Working memory findings were also largely consistent with previous research suggesting limited OC-related effects in this domain (for a review, see Gurvich et al., 2023), except for one study which argued that OC effects may emerge when tasks require proactive control (Gravelsins et al., 2021), which was not directly assessed by our executive control battery. Taken together, these findings suggest that executive control, as reflected by our composite measure, may be too

general a construct to capture subtle OC-related effects unless specific processes (e.g., proactive control) and moderating variables (e.g., OC use duration) are considered.

4.5 Thesis limitations and future research directions

Several strengths and limitations of the present thesis have already been discussed in previous chapters. However, certain methodological considerations, namely the lack of objective hormone measurements, the absence of a male comparison group, and possible sampling bias, warrant further attention as they may have important implications for how the present findings should be interpreted. These limitations, along with broader directions for future OC research, are discussed in the following section.

4.5.1 *Lack of objective hormone measurements*

A key limitation of the present thesis, particularly Study 3, is the absence of hormone assays, which would have allowed us to quantify endogenous ovarian hormone levels and verify menstrual cycle stage among naturally cycling participants. Without these measures, we relied on self-reported menstrual cycle and pill phase timing, which is a recommended alternative when hormone assays are not feasible, despite not being as sensitive a method (see Beltz, 2022). This limitation is especially relevant because, although combined OCs suppress circulating endogenous hormones to levels comparable to the early follicular phase (e.g., De Bondt et al., 2013; Sahlberg et al., 1987), the extent to which these hormones are suppressed may vary depending on the specific OC formulation (see Taylor et al., 2021). Therefore, hormone assays would have been particularly useful for characterizing hormone suppression among OC users. As a result, our cognitive findings cannot be attributed to specific hormone types or concentrations and therefore should be interpreted with caution.

Moreover, OC use involves both the suppression of endogenous hormones and the administration of exogenous hormones, making it difficult to disentangle their respective neurobiological and cognitive effects without the use of precise hormonal methods. Given that most commercially available hormone assays do not accurately detect synthetic hormone concentrations (Hampson, 2023), future research would benefit from using more sensitive assay methods (e.g., Blue et al., 2018; Zhang et al., 2019), possibly combined with longitudinal dense-sampling designs that examine hormonal fluctuations and associated structural and/or functional brain changes across a full menstrual or OC cycle (e.g., Heller et al., 2025; Taylor et al., 2020; Zsido et al., 2023). Such approaches would help clarify the contributions of endogenous ovarian hormones, synthetic OC hormones, and other hormone systems potentially involved in OC-cognition interactions, such as testosterone, LH/FSH, and HPA-axis function.

4.5.2 *Exclusion of male controls*

A related limitation was our decision to not include a male control group in Study 3, which could have provided a useful point of reference for interpreting the magnitude and direction of OC-related effects in domains where sex- and gender-related differences are well established, such as verbal learning and memory (Asperholm et al., 2019) and visuospatial ability (Voyer et al., 1995). Male participants were not included in Study 3 for two reasons: First, we had limited time and resources for this study and therefore prioritized the recruitment of new OC users. Second, because our main variable of interest was verbal memory, which shows a female advantage, we already expected to see a difference between male and female participants on our battery (i.e., medium-to-large effect size; Jensen et al., 2023). Nevertheless, including male participants could have helped us contextualize subtle OC-related effects on subjective memory, which remain poorly understood and documented in the literature. It could also clarify the

potential role of testosterone-related mechanisms in cognition given that OCs may substantially reduce testosterone levels in users (Zimmerman et al., 2014). Relatedly, given that not all HC users identify as women, future studies should distinguish between sex assigned at birth and gender-related variables (i.e., gender identity, roles, and self-concept), as these may interact with OC use and cognition in distinct ways (Beltz et al., 2022; Pletzer et al., 2015b).

4.5.3 Potential sampling bias

A key strength of this thesis was the use of a quasi-experimental longitudinal design, which allowed us to examine episodic memory before and after OC initiation. However, because choosing to use or not to use OCs is an inherently personal decision, sampling bias remains a concern in almost all OC research. Individuals who initiate OCs may differ systematically from non-users in ways that are difficult to control, including relationship status, reproductive history, health concerns, healthcare access, and personal attitudes toward HC use (e.g., Pletzer, 2019; Warren et al., 2014; Westhoff et al., 2007). For example, in Study 3, a higher proportion of new and current OC users were in a serious relationship compared to naturally cycling participants, whereas a higher proportion of naturally cycling participants were single. OC users may also reflect a *survivor effect* whereby individuals who experience negative physiological or psychological side effects are more likely to discontinue early, whereas those who tolerate OCs are more likely to be represented in longitudinal study samples (Kulkarni, 2007; Kurshan & Epperson, 2006; Sanders et al., 2001; Skovlund et al., 2016; Toffol et al., 2011; Westhoff et al., 2007). Additionally, preexisting premenstrual symptoms and mood disorders (e.g., depression, anxiety) may predict future OC discontinuation (Stevens et al., 2026). These factors may be particularly relevant when interpreting differences between new and established OC users, as well as participant attrition. Future quasi-experimental or longitudinal studies should try to

document reasons for OC discontinuation and study dropout, while also accounting for baseline differences between users and non-users wherever possible.

4.6 Additional considerations for future OC research

Additional recommendations and opportunities may be important for future research. First, although several systematic reviews on the associations between OC use and various cognitive domains (Beltz, 2022; Gurvich et al., 2023; Warren et al., 2014), as well as one meta-analysis on executive control (Kowalczyk et al., 2023), have been published in recent years, the field may soon benefit from a meta-analysis focused specifically on the OC-memory relationship. Such a meta-analysis would help clarify the overall direction and magnitude of these effects and determine whether inconsistencies across studies reflect actual variability in OC effects or rather methodological differences in OC-related factors (e.g., formulation, dosage), task selection, or comparison groups (e.g., naturally cycling controls measured at different menstrual phases). However, there exists substantial study-to-study variability with respect to the inclusion of cognitive tasks and batteries, OC types, comparison groups, and covariates (see Gurvich et al., 2023), which should be taken into account when determining sample size and selecting the analytical approach for a meta-analysis (i.e., fixed- vs. random-effects models; Cheung & Vijayakumar, 2016; Valentine et al., 2010).

Second, future research examining the link between OC use and subjective memory could benefit from integrating qualitative and mixed-methods approaches, such as interviews, daily diaries, or ecological momentary assessments, to capture richer information about people's lived experiences before and/or after initiating OCs. Such assessments could also include open-ended descriptions of memory difficulties, memory lapses, and other perceived cognitive changes, alongside brief psychological and cognitive assessments. This would allow researchers

to compare objective performance with subjective experiences over time and better understand whether perceived memory changes reflect cognitive differences, emotional or stress-related factors, or adjustment to OC use more generally.

Third, future studies should consider the role of stress in the OC-memory relationship. No stress measures were included in the present thesis, first because previous work from our lab found no convincing associations with a self-reported stress questionnaire (Jensen et al., 2023), and second because we wished to limit the number of testing variables included in Study 3 so as to not over-burden participants. However, growing evidence suggests that OC use can interact with the HPA axis to modulate cortisol levels and blunt stress responses (Hertel et al., 2017; Kirschbaum et al., 1999; Roche et al., 2013; Sharma et al., 2020b). This link might be relevant for memory given the well-established role of stress and glucocorticoids in episodic memory encoding, consolidation, and retrieval (Gagnon & Wagner, 2016; Goldfarb, 2019; Segal et al., 2014; Shields et al., 2017). In fact, OC use may reduce the detrimental effects of stress on episodic memory, with some studies showing maintained or improved recall following acute stress exposure in OC users (Kuhlmann & Wolf, 2005; Merz, 2017; Nielsen et al., 2014; for a review, see Jentsch et al., 2022). Future research should therefore consider incorporating objective and/or subjective measures of stress to more closely examine how stress-related mechanisms may be associated with memory functioning in OC users.

Finally, although OCs remain a very common birth control option, hormonal IUDs have become increasingly popular in recent years, surpassing OCs as the most widely used form of HC as of 2022 (United Nations, 2022). Consistent with this, the field is also expanding to include more research on IUDs specifically (Beltz et al., 2022; Yan et al., 2025). These developments do not discount the importance of studying OCs but rather mark an opportunity to integrate research

across various forms of HCs. Doing so would shed light on which cognitive effects are specific to one contraceptive method, and which are related to more general consequences of HC use.

4.7 Conclusion

The present dissertation contributes to a more nuanced understanding of the ways in which OC use relates to objective and subjective memory in young female adults. Specifically, this research highlights the potential importance of OC timing and duration of use and, to the best of my knowledge, is the first to examine associations between OC use and subjective memory ratings. In discussing my findings, I have also outlined several directions for future research, including the need to integrate different methodological approaches, sensitive hormonal measurements, participant samples, and forms of HC, while also considering important confounding variables such as stress, gender, language, OC formulation, and reproductive history.

As this area of research continues to evolve, however, it will also be important to consider how scientific findings are communicated beyond the academic literature. Recent research suggests that young women's knowledge about HCs is relatively limited, especially regarding their mechanisms of action, side effects, and appropriate use (Leong et al., 2026). This limited knowledge, combined with the widespread use of HCs across the globe, underscores the importance of not only continuing to build a high-quality body of work, but also ensuring that it is translated into accessible and accurate information for the general population. I therefore hope that the findings and recommendations outlined in this thesis will contribute to ongoing research in this field while also supporting efforts aimed at disseminating HC-related knowledge in ways that help women make more informed contraceptive decisions.

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REFERENCES

- Abma, J. C., & Martinez, G. M. (2023). Teenagers in the United States: Sexual Activity, Contraceptive Use, and Childbearing, 2015-2019. *National Health Statistics Reports*, (196), 1–23.
- Akıncı, B., Oğul, Ö. E., Hanoğlu, L., Kulaç, B., Ören, D., Ulu, O., & Basançelebi, B. (2023). Evaluation of cognitive functions in adult individuals with COVID-19. *Neurological Sciences*, 44(3), 793–802. <https://doi.org/10.1007/s10072-022-06562-2>
- Almey, A., Milner, T. A., & Brake, W. G. (2015). Estrogen receptors in the central nervous system and their implication for dopamine-dependent cognition in females. *Hormones and Behavior, Estradiol and Cognition: Molecules to Mind*, 74, 125–138. <https://doi.org/10.1016/j.yhbeh.2015.06.010>
- Alvarez, J. A., & Emory, E. (2006). Executive Function and the Frontal Lobes: A Meta-Analytic Review. *Neuropsychology Review*, 16(1), 17–42. <https://doi.org/10.1007/s11065-006-9002-x>
- Amariglio, R. E., Frishe, K., Olson, L. E., Wadsworth, L. P., Lorus, N., Sperling, R. A., & Rentz, D. M. (2012). Validation of the Face Name Associative Memory Exam in cognitively normal older individuals. *Journal of Clinical and Experimental Neuropsychology*, 34(6), 580–587. <https://doi.org/10.1080/13803395.2012.666230>
- Anderl, C., de Wit, A. E., Giltay, E. J., Oldehinkel, A. J., & Chen, F. S. (2022). Association between adolescent oral contraceptive use and future major depressive disorder: A prospective cohort study. *Journal of Child Psychology and Psychiatry*, 63(3), 333–341. <https://doi.org/10.1111/jcpp.13476>
- Andreano, J. M., & Cahill, L. (2009). Sex influences on the neurobiology of learning and memory. *Learning & Memory*, 16(4), 248–266. <https://doi.org/10.1101/lm.918309>

- Andresen, E. M., Malmgren, J. A., Carter, W. B., & Patrick, D. L. (1994). Screening for Depression in Well Older Adults: Evaluation of a Short Form of the CES-D. *American Journal of Preventive Medicine*, 10(2), 77–84. [https://doi.org/10.1016/S0749-3797\(18\)30622-6](https://doi.org/10.1016/S0749-3797(18)30622-6)
- Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N.Z., & Evershed, J. K. (2020). Gorilla in our midst: an online behavioural experiment builder. *Behavior Research Methods*, 52, 388–407. <https://doi.org/10.3758/s13428-019-01237-x>
- Arrow, K., Resnik, P., Michel, H., Kitchen, C., Mo, C., Chen, S., Espy-Wilson, C., Coppersmith, G., Frazier, C., & Kelly, D. L. (2023). Evaluating the use of online self-report questionnaires as clinically valid mental health monitoring tools in the clinical whitespace. *Psychiatric Quarterly*, 94(2), 221–231. <https://doi.org/10.1007/s11126-023-10022-1>
- Aschwanden, D., Sutin, A. R., Luchetti, M., Allemand, M., Stephan, Y., & Terracciano, A. (2020). A systematic review and meta-analysis of the association between personality and cognitive failures/complaints. *Social and Personality Psychology Compass*, 14(11), e12565. <https://doi.org/10.1111/spc3.12565>
- Asperholm, M., Högman, N., Rafi, J., & Herlitz, A. (2019). What did you do yesterday? A meta-analysis of sex differences in episodic memory. *Psychological Bulletin*, 145(8), 785–821. <https://doi.org/10.1037/bul0000197>
- Atkinson, R. C., & Shiffrin, R. M. (1968). Human Memory: A Proposed System and its Control Processes1. In K. W. Spence & J. T. Spence (Eds.), *Psychology of Learning and Motivation* (Vol. 2, pp. 89–195). Academic Press. [https://doi.org/10.1016/S0079-7421\(08\)60422-3](https://doi.org/10.1016/S0079-7421(08)60422-3)
- Azcoitia, I., Yague, J. G., & Garcia-Segura, L. M. (2011). Estradiol synthesis within the human brain. *Neuroscience, Neuroactive Steroids: Focus on Human Brain*, 191, 139–147. <https://doi.org/10.1016/j.neuroscience.2011.02.012>

- Backx, R., Skirrow, C., Dente, P., Barnett, J. H., & Cormack, F. K. (2020). Comparing Web-Based and Lab-Based Cognitive Assessment Using the Cambridge Neuropsychological Test Automated Battery: A Within-Subjects Counterbalanced Study. *Journal of Medical Internet Research*, 22(8), e16792. <https://doi.org/10.2196/16792>
- Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, 4(11), 417–423. [https://doi.org/10.1016/S1364-6613\(00\)01538-2](https://doi.org/10.1016/S1364-6613(00)01538-2)
- Bainbridge, W. A., Isola, P., & Oliva, A. (2013). The intrinsic memorability of face photographs. *Journal of Experimental Psychology: General*, 142(4), 1323–1334. <https://doi.org/10.1037/a0033872>
- Bali, N., Arimoto, J. M., Iwata, N., Lin, S. W., Zhao, L., Brinton, R. D., Morgan, T. E., & Finch, C. E. (2012). Differential Responses of Progesterone Receptor Membrane Component-1 (Pgrmc1) and the Classical Progesterone Receptor (Pgr) to 17 β -Estradiol and Progesterone in Hippocampal Subregions that Support Synaptic Remodeling and Neurogenesis. *Endocrinology*, 153(2), 759–769. <https://doi.org/10.1210/en.2011-1699>
- Barros, L. A., Tufik, S., & Andersen, M. L. (2015). The role of progesterone in memory: An overview of three decades. *Neuroscience and Biobehavioral Reviews*, 49, 193–204. <https://doi.org/10.1016/j.neubiorev.2014.11.015>
- Barth, C., Steele, C. J., Mueller, K., Rekkas, V. P., Arélin, K., Pampel, A., Burmann, I., Kratzsch, J., Villringer, A., & Sacher, J. (2016). In-vivo Dynamics of the Human Hippocampus across the Menstrual Cycle. *Scientific Reports*, 6, 32833. <https://doi.org/10.1038/srep32833>
- Barth, C., Villringer, A., & Sacher, J. (2015). Sex hormones affect neurotransmitters and shape the adult female brain during hormonal transition periods. *Frontiers in Neuroscience*, 9. <https://www.frontiersin.org/article/10.3389/fnins.2015.00037>

- Bartholomaeus, V., Chronowski, N. H., Santiago, P. H. R., Kuring, J. K., & Sawyer, A. (2024). Equivalence of telehealth and face-to-face administration of the Wechsler Adult Intelligence Scale Fourth Edition (WAIS-IV). *The Clinical Neuropsychologist*, 39(5), 1073-1096.
<https://doi.org/10.1080/13854046.2024.2335117>
- Batur, P., Elder, J., & Mayer, M. (2003). Update on contraception: Benefits and risks of the new formulations. *Cleveland Clinic Journal of Medicine*, 70(8), 681–682, 685–686, 668-90 passim.
<https://doi.org/10.3949/ccjm.70.8.681>
- Becker, J. B., & Hu, M. (2008). Sex differences in drug abuse. *Frontiers in Neuroendocrinology*, 29(1), 36–47. <https://doi.org/10.1016/j.yfrne.2007.07.003>
- Becker, L., Schade, U., & Rohleder, N. (2020). Activation of the hypothalamic-pituitary adrenal axis in response to a verbal fluency task and associations with task performance. *PLOS ONE*, 15(4), e0227721. <https://doi.org/10.1371/journal.pone.0227721>
- Bégin-Galarneau, M-È. (2019). Self-ratings of memory in Parkinson’s disease: Relation to depressive symptoms, personality and executive functions [Thesis]. Université d’Ottawa / University of Ottawa. <https://doi.org/10.20381/ruor-23455>
- Bell, T., Hill, N., & Stavrinou, D. (2020). Personality determinants of subjective executive function in older adults. *Aging & Mental Health*, 24(11), 1935–1944.
<https://doi.org/10.1080/13607863.2019.1667300>
- Belleville, S., LaPlume, A. A., & Purkart, R. (2023). Web-based cognitive assessment in older adults: Where do we stand? *Current Opinion in Neurology*, 36(5), 491.
<https://doi.org/10.1097/WCO.0000000000001192>

- Beltz, A. M. (2022). Hormonal contraceptive influences on cognition and psychopathology: Past methods, present inferences, and future directions. *Frontiers in Neuroendocrinology*, 67, 101037. <https://doi.org/10.1016/j.yfrne.2022.101037>
- Beltz, A. M. (2024). Hormonal contraceptives and behavior: Updating the potent state of the nascent science. *Hormones and Behavior*, 164, 105574. <https://doi.org/10.1016/j.yhbeh.2024.105574>
- Beltz, A. M., Demidenko, M. I., Chaku, N., Klump, K. L., & Joseph, J. E. (2022). Intrauterine Device Use: A New Frontier for Behavioral Neuroendocrinology. *Frontiers in Endocrinology*, 13. <https://doi.org/10.3389/fendo.2022.853714>
- Beltz, A. M., Hampson, E., & Berenbaum, S. A. (2015). Oral contraceptives and cognition: A role for ethinyl estradiol. *Hormones and Behavior*, 74, 209–217. <https://doi.org/10.1016/j.yhbeh.2015.06.012>
- Beltz, A. M., Loviska, A. M., & Kelly, D. (2019). No personality differences between oral contraceptive users and naturally cycling women: Implications for research on sex hormones. *Psychoneuroendocrinology*, 100, 127–130. <https://doi.org/10.1016/j.psyneuen.2018.09.034>
- Beltz, A. M., & Moser, J. S. (2020). Ovarian hormones: A long overlooked but critical contributor to cognitive brain structures and function. *Annals of the New York Academy of Sciences*, 1464(1), 156–180. <https://doi.org/10.1111/nyas.14255>
- Bengtsdotter, H., Lundin ,Cecilia, Gemzell Danielsson ,Kristina, Bixo ,Marie, Baumgart ,Juliane, Marions ,Lena, Brynhildsen ,Jan, Malmborg ,Agota, Lindh ,Ingela, & and Sundström Poromaa, I. (2018). Ongoing or previous mental disorders predispose to adverse mood reporting during combined oral contraceptive use. *The European Journal of Contraception & Reproductive Health Care*, 23(1), 45–51. <https://doi.org/10.1080/13625187.2017.1422239>

Blair, J. A., Bhatta, S., McGee, H., & Casadesus, G. (2015). Luteinizing hormone: Evidence for direct action in the CNS. *Hormones and Behavior*, 76, 57–62.

<https://doi.org/10.1016/j.yhbeh.2015.06.020>

Blakemore, S.-J. (2012). Imaging brain development: The adolescent brain. *NeuroImage*, *NEUROIMAGING: THEN, NOW AND THE FUTURE*, 61(2), 397–406.

<https://doi.org/10.1016/j.neuroimage.2011.11.080>

Blue, S. W., Winchell, A. J., Kaucher, A. V., Lieberman, R. A., Gilles, C. T., Pyra, M. N., Heffron, R., Hou, X., Coombs, R. W., Nanda, K., Davis, N. L., Kourtis, A. P., Herbeck, J. T., Baeten, J. M., Lingappa, J. R., & Erikson, D. W. (2018). Simultaneous quantitation of multiple contraceptive hormones in human serum by LC-MS/MS. *Contraception*, 97(4), 363–369.

<https://doi.org/10.1016/j.contraception.2018.01.015>

Blumenfeld, R. S., & Ranganath, C. (2007). Prefrontal Cortex and Long-Term Memory Encoding: An Integrative Review of Findings from Neuropsychology and Neuroimaging. *The Neuroscientist*, 13(3), 280–291. <https://doi.org/10.1177/1073858407299290>

Bottenhorn, K. L., Salo, T., Jacobs, E. G., Pritschet, L., Taylor, C., Herting, M. M., & Laird, A. R. (2025). Idiosyncrasy and generalizability of contraceptive- and hormone-related functional connectomes across the menstrual cycle. *Network Neuroscience*, 9(3), 990–1012.

<https://doi.org/10.1162/netn.a.20>

Brearly, T. W., Shura, R. D., Martindale, S. L., Lazowski, R. A., Luxton, D. D., Shenal, B. V., & Rowland, J. A. (2017). Neuropsychological Test Administration by Videoconference: A Systematic Review and Meta-Analysis. *Neuropsychology Review*, 27(2), 174–186.

<https://doi.org/10.1007/s11065-017-9349-1>

- Brinton, R. D., Thompson, R. F., Foy, M. R., Baudry, M., Wang, J., Finch, C. E., Morgan, T. E., Pike, C. J., Mack, W. J., Stanczyk, F. Z., & Nilsen, J. (2008). Progesterone receptors: Form and function in brain. *Frontiers in Neuroendocrinology, Rapid Actions of Steroid Hormones*, 29(2), 313–339. <https://doi.org/10.1016/j.yfrne.2008.02.001>
- Brønneck, M. K., Økland, I., Graugaard, C., & Brønneck, K. K. (2020). The Effects of Hormonal Contraceptives on the Brain: A Systematic Review of Neuroimaging Studies. *Frontiers in Psychology*, 11. <https://doi.org/10.3389/fpsyg.2020.556577>
- Bronson, R. A. (1981). ORAL CONTRACEPTION: MECHANISM OF ACTION. *Clinical Obstetrics and Gynecology*, 24(3), 869.
- Brown, A., Burles, F., Iaria, G., Einstein, G., & Moscovitch, M. (2023). Sex and menstrual cycle influence human spatial navigation strategies and performance. *Scientific Reports*, 13(1), 14953. <https://doi.org/10.1038/s41598-023-41153-x>
- Brown, F. C., O'Connor, B. P., Vitelli, K. M., Heinly, M., Rommel, G. C., & Davis, R. N. (2018). Comparison of the Computer and Hand Administered Versions of the Brown Location Test (BLT). *Archives of Clinical Neuropsychology*, 33(1), 47–56. <https://doi.org/10.1093/arclin/acx049>
- Brown, T. A. (2006). *Confirmatory factor analysis* for applied researchers. New York: NY.
- Brown, T., & Zakzanis, K. K. (2023). A review of the reliability of remote neuropsychological assessment. *Applied Neuropsychology: Adult*, 32(5), 1536-1542. <https://doi.org/10.1080/23279095.2023.2279208>
- Burles, F., & Iaria, G. (2020). Behavioural and cognitive mechanisms of Developmental Topographical Disorientation. *Scientific Reports*, 10(1), 20932. <https://doi.org/10.1038/s41598-020-77759-8>

- Burmester, B., Leathem, J., & Merrick, P. (2015). Assessing subjective memory complaints: A comparison of spontaneous reports and structured questionnaire methods. *International Psychogeriatrics*, 27(1), 61–77. <https://doi.org/10.1017/S1041610214001161>
- Cahill, L. (2018). How does hormonal contraception affect the developing human adolescent brain? *Current Opinion in Behavioral Sciences, Sex and Gender*, 23, 131–135. <https://doi.org/10.1016/j.cobeha.2018.06.015>
- Caillaud, M., Hudon, C., Boller, B., Brambati, S., Duchesne, S., Lorrain, D., Gagnon, J.-F., Maltezos, S., Mellah, S., Phillips, N., Consortium for the Early Identification of Alzheimer’s Disease-Quebec, & Belleville, S. (2020). Evidence of a Relation Between Hippocampal Volume, White Matter Hyperintensities, and Cognition in Subjective Cognitive Decline and Mild Cognitive Impairment. *The Journals of Gerontology: Series B*, 75(7), 1382–1392. <https://doi.org/10.1093/geronb/gbz120>
- Campelo, G., Zortea, M., Saraiva, R., Machado, W., Sbicigo, J. B., Segabinazi, J. D., Gastal, C., de Castilho, G. M., & Salles, J. F. (2016). A short version of the questionnaire of metamemory in Adulthood (MIA) in Portuguese. *Psicologia: Reflexão e Crítica*, 29(1), 37. <https://doi.org/10.1186/s41155-016-0043-7>
- Cantegreil-Kallen, I., & Pin, S. (2012). Fear of Alzheimer’s disease in the French population: Impact of age and proximity to the disease. *International Psychogeriatrics*, 24(1), 108–116. <https://doi.org/10.1017/S1041610211001529>
- Carson, N., Leach, L., & Murphy, K. J. (2018). A re-examination of montreal cognitive assessment (MoCA) cutoff scores. *International Journal of Geriatric Psychiatry*, 33(2), 379–388. <https://doi.org/10.1002/gps.4756>

- Chan, D., Gallaher, L. M., Moodley, K., Minati, L., Burgess, N., & Hartley, T. (2016). The 4 Mountains Test: A Short Test of Spatial Memory with High Sensitivity for the Diagnosis of Pre-dementia Alzheimer's Disease. *JoVE (Journal of Visualized Experiments)*, 116, e54454. <https://doi.org/10.3791/54454>
- Chan, J. C. K., & McDermott, K. B. (2007). The effects of frontal lobe functioning and age on veridical and false recall. *Psychonomic Bulletin & Review*, 14(4), 606–611. <https://doi.org/10.3758/BF03196809>
- Chan, M.-F., Dowsett, M., Folkerd, E., Wareham, N., Luben, R., Welch, A., Bingham, S., & Khaw, K.-T. (2008). Past oral contraceptive and hormone therapy use and endogenous hormone concentrations in postmenopausal women. *Menopause*, 15(2), 332–339. <https://doi.org/10.1097/gme.0b013e31806458d9>
- Chaytor, N., & Schmitter-Edgecombe, M. (2003). The Ecological Validity of Neuropsychological Tests: A Review of the Literature on Everyday Cognitive Skills. *Neuropsychology Review*, 13(4), 181–197. <https://doi.org/10.1023/B:NERV.0000009483.91468.fb>
- Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, 14(3), 464–504. <https://doi.org/10.1080/10705510701301834>
- Cheung, M. W.-L., & Vijayakumar, R. (2016). A Guide to Conducting a Meta-Analysis. *Neuropsychology Review*, 26(2), 121–128. <https://doi.org/10.1007/s11065-016-9319-z>
- Chin, J., Oh, K. J., Seo, S. W., & Na, D. L. (2014). Are depressive symptomatology and self-focused attention associated with subjective memory impairment in older adults? *International Psychogeriatrics*, 26(4), 573–580. <https://doi.org/10.1017/S104161021300241X>

- Christin-Maitre, S. (2013). History of oral contraceptive drugs and their use worldwide. *Best Practice & Research Clinical Endocrinology & Metabolism, Oral Contraceptive Drugs*, 27(1), 3–12.
<https://doi.org/10.1016/j.beem.2012.11.004>
- Colzato, L. S., Pratt, J., & Hommel, B. (2012). Estrogen modulates inhibition of return in healthy human females. *Neuropsychologia*, 50(1), 98–103.
<https://doi.org/10.1016/j.neuropsychologia.2011.11.003>
- Concas, A., Serra, M., & Porcu, P. (2022). How hormonal contraceptives shape brain and behavior: A review of preclinical studies. *Frontiers in Neuroendocrinology*, 66, 101017.
<https://doi.org/10.1016/j.yfrne.2022.101017>
- Cooper, D. B., & Patel, P. (2025). Oral Contraceptive Pills. In *StatPearls*. StatPearls Publishing.
<http://www.ncbi.nlm.nih.gov/books/NBK430882/>
- Costa, P. T., Jr., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: Robust and surprising findings. *Journal of Personality and Social Psychology*, 81(2), 322–331. <https://doi.org/10.1037/0022-3514.81.2.322>
- Coughlan, G., DeSouza, B., Zhukovsky, P., Hornberger, M., Grady, C., & Buckley, R. F. (2023). Spatial cognition is associated with levels of phosphorylated-tau and β -amyloid in clinically normal older adults. *Neurobiology of Aging*, 130, 124–134.
<https://doi.org/10.1016/j.neurobiolaging.2023.06.016>
- Creinin, M. D., Keverline, S., & Meyn, L. A. (2004). How regular is regular? An analysis of menstrual cycle regularity. *Contraception*, 70(4), 289–292.
<https://doi.org/10.1016/j.contraception.2004.04.012>

- Crumley, J. J., Stetler, C. A., & Horhota, M. (2014). Examining the relationship between subjective and objective memory performance in older adults: A meta-analysis. *Psychology and Aging*, 29(2), 250–263. <https://doi.org/10.1037/a0035908>
- Csábi, E., Hallgató, E., & Volosin, M. (2023). The association between metamemory, subjective memory complaints, mood, and well-being: The Hungarian validation of Multifactorial Memory Questionnaire. *Cognitive Research: Principles and Implications*, 8(1), Article 1. <https://doi.org/10.1186/s41235-023-00469-y>
- Csábi, E., Kovács, F. M., & Volosin, M. (2025). Predictors of subjective memory functioning in young adults. *BMC Psychiatry*, 25, 155. <https://doi.org/10.1186/s12888-025-06568-y>
- Curtis, K. M., Tepper, N. K., Jatlaoui, T. C., Berry-Bibee, E., Horton, L. G., Zapata, L. B., Simmons, K. B., Pagano, H. P., Jamieson, D. J., & Whiteman, M. K. (2016). U.S. Medical Eligibility Criteria for Contraceptive Use, 2016. *MMWR. Recommendations and Reports: Morbidity and Mortality Weekly Report. Recommendations and Reports*, 65(3), 1–103. <https://doi.org/10.15585/mmwr.rr6503a1>
- Cutler, S. J. (2015). Worries about getting Alzheimer's: Who's concerned? *American Journal of Alzheimer's Disease & Other Dementias®*, 30(6), 591–598. <https://doi.org/10.1177/1533317514568889>
- Cyr, A.-A., Romero, K., & Galin-Corini, L. (2021). Web-Based Cognitive Testing of Older Adults in Person Versus at Home: Within-Subjects Comparison Study. *JMIR Aging*, 4(1), e23384. <https://doi.org/10.2196/23384>
- Daley, R. T., Bowen, H. J., Fields, E. C., Parisi, K. R., Gutchess, A., & Kensinger, E. A. (2024). Individual Differences in Older Adult Frontal Lobe Function Relate to Memory and Neural

- Activity for Self-Relevant and Emotional Content. *The Journals of Gerontology: Series B*, 79(3), gbad186. <https://doi.org/10.1093/geronb/gbad186>
- Davidson, P. S. R., & Jensen, A. (2022). Executive function and episodic memory composite scores in older adults: Relations with sex, mood, and subjective sleep quality. *Aging, Neuropsychology, and Cognition*, 0(0), 1–24. <https://doi.org/10.1080/13825585.2022.2086682>
- Davignon, L.-M., Brouillard, A., Juster, R.-P., & Marin, M.-F. (2024). The role of sex hormones, oral contraceptive use, and its parameters on visuospatial abilities, verbal fluency, and verbal memory. *Hormones and Behavior*, 157, 105454. <https://doi.org/10.1016/j.yhbeh.2023.105454>
- Davis, D. K., Alea, N., & Bluck, S. (2015). The Difference between Right and Wrong: Accuracy of Older and Younger Adults' Story Recall. *International Journal of Environmental Research and Public Health*, 12(9), 10861–10885. <https://doi.org/10.3390/ijerph120910861>
- De Bondt, T., Jacquemyn, Y., Van Hecke, W., Sijbers, J., Sunaert, S., & Parizel, P. M. (2013). Regional gray matter volume differences and sex-hormone correlations as a function of menstrual cycle phase and hormonal contraceptives use. *Brain Research*, 1530, 22–31. <https://doi.org/10.1016/j.brainres.2013.07.034>
- De Bondt, T., Pullens, P., Van Hecke, W., Jacquemyn, Y., & Parizel, P. M. (2016). Reproducibility of hormone-driven regional grey matter volume changes in women using SPM8 and SPM12. *Brain Structure & Function*, 221(9), 4631–4641. <https://doi.org/10.1007/s00429-016-1193-1>
- De Leo, V., Musacchio, M. C., Cappelli, V., Piomboni, P., & Morgante, G. (2016). Hormonal contraceptives: Pharmacology tailored to women's health. *Human Reproduction Update*, 22(5), 634–646. <https://doi.org/10.1093/humupd/dmw016>

- Derouesné, C., Lacomblez, L., Thibault, S., & Leponcin, M. (1999). Memory complaints in young and elderly subjects. *International Journal of Geriatric Psychiatry*, 14(4), 291–301.
[https://doi.org/10.1002/\(SICI\)1099-1166\(199904\)14:4<291::AID-GPS902>3.0.CO;2-7](https://doi.org/10.1002/(SICI)1099-1166(199904)14:4<291::AID-GPS902>3.0.CO;2-7)
- Dhont, M. (2010). History of oral contraception. *The European Journal of Contraception & Reproductive Health Care*, 15(sup2), S12–S18. <https://doi.org/10.3109/13625187.2010.513071>
- Dickey, R. P., & Seymour, M. L. (2021). *Managing contraceptive pill patients and other hormonal contraceptives*. EMIS Incorporated Medical Publishers.
- DiLiberti, C. E., O’Leary, C. M., Hendy, C. H., Waters, D. H., & Margolis, M. B. (2011). Steady-state pharmacokinetics of an extended-regimen oral contraceptive with continuous estrogen. *Contraception*, 83(1), 55–61. <https://doi.org/10.1016/j.contraception.2010.06.015>
- Dixon, R. A., & Hultsch, D. F. (1988). Metamemory in adulthood questionnaire. Handbook for clinical memory assessment of older adults. [Database record]. APA PsycTests.
<https://doi.org/10.1037/t02356-000>
- Drouin, H. (2017). The effects of aging and cognitive strategies on associative memory: Not all associations are created equal [Thesis]. Université d’Ottawa / University of Ottawa.
<https://doi.org/10.20381/ruor-20977>
- Dubol, M., Epperson, C. N., Sacher, J., Pletzer, B., Derntl, B., Lanzenberger, R., Sundström-Poromaa, I., & Comasco, E. (2021). Neuroimaging the menstrual cycle: A multimodal systematic review. *Frontiers in Neuroendocrinology*, 60, 100878. <https://doi.org/10.1016/j.yfrne.2020.100878>
- Duke, J. M., Sibbritt, D. W., & Young, A. F. (2007). Is there an association between the use of oral contraception and depressive symptoms in young Australian women? *Contraception*, 75(1), 27–31. <https://doi.org/10.1016/j.contraception.2006.08.002>

- Dwyer, A. A., & Quinton, R. (2019). Anatomy and Physiology of the Hypothalamic-Pituitary-Gonadal (HPG) Axis. In *Advanced Practice in Endocrinology Nursing* (pp. 839–852). Springer, Cham. https://doi.org/10.1007/978-3-319-99817-6_43
- Egan, K. R., & Gleason, C. E. (2012). Longer duration of hormonal contraceptive use predicts better cognitive outcomes later in life. *Journal of Women's Health* (2002), 21(12), 1259–1266. <https://doi.org/10.1089/jwh.2012.3522>
- Ehrlich, E., Gibson, T., & Mark, T. (2011). Trends in prescriptions for oral contraceptives among US teenagers. *Truven Health Analytics*.
- Eid, R. S., Gobinath, A. R., & Galea, L. A. M. (2019). Sex differences in depression: Insights from clinical and preclinical studies. *Progress in Neurobiology*, 176, 86–102. <https://doi.org/10.1016/j.pneurobio.2019.01.006>
- Elliott-Sale, K. J., Smith, S., Bacon, J., Clayton, D., McPhilimey, M., Goutianos, G., Hampson, J., & Sale, C. (2013). Examining the role of oral contraceptive users as an experimental and/or control group in athletic performance studies. *Contraception*, 88(3), 408–412. <https://doi.org/10.1016/j.contraception.2012.11.023>
- Enriquez-Geppert, S., Flores-Vázquez, J. F., Lietz, M., Garcia-Pimenta, M., & Andrés, P. (2021). I know your face but can't remember your name: Age-related differences in the FNAME-12NL. *Archives of Clinical Neuropsychology*, 36(5), 844–849. <https://doi.org/10.1093/arclin/aaaa107>
- Escande, A., Pillon, A., Servant, N., Cravedi, J.-P., Larrea, F., Muhn, P., Nicolas, J.-C., Cavaillès, V., & Balaguer, P. (2006). Evaluation of ligand selectivity using reporter cell lines stably expressing estrogen receptor alpha or beta. *Biochemical Pharmacology*, 71(10), 1459–1469. <https://doi.org/10.1016/j.bcp.2006.02.002>

- Ferretti, M. T., Iulita, M. F., Cavedo, E., Chiesa, P. A., Schumacher Dimech, A., Santucci Chadha, A., Baracchi, F., Girouard, H., Misoch, S., Giacobini, E., Depypere, H., & Hampel, H. (2018). Sex differences in Alzheimer disease—The gateway to precision medicine. *Nature Reviews Neurology*, 14(8), Article 8. <https://doi.org/10.1038/s41582-018-0032-9>
- Finney, C. A., Shvetsov, A., Westbrook, R. F., Jones, N. M., & Morris, M. J. (2020). The role of hippocampal estradiol in synaptic plasticity and memory: A systematic review. *Frontiers in Neuroendocrinology*, 56, 100818. <https://doi.org/10.1016/j.yfrne.2019.100818>
- Ford, N., Slade, P., & Butler, G. (2004). An absence of evidence linking perceived memory problems to the menopause. *British Journal of General Practice*, 54(503), 434–438.
- Fort, I., Adoul, L., Holl, D., Kaddour, J., & Gana, K. (2004). Psychometric Properties of the French Version of the Multifactorial Memory Questionnaire for Adults and the Elderly. *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, 23(4), 347–357. <https://doi.org/10.1353/cja.2005.0020>
- Frick, K. M. (2015). Molecular mechanisms underlying the memory-enhancing effects of estradiol. *Hormones and Behavior, Estradiol and Cognition: Molecules to Mind*, 74, 4–18. <https://doi.org/10.1016/j.yhbeh.2015.05.001>
- Fritsch, T., McClendon, M. J., Wallendal, M. S., Hyde, T. F., & Larsen, J. D. (2014). Prevalence and cognitive bases of subjective memory complaints in older adults: Evidence from a community sample. *Journal of Neurodegenerative Diseases*, 2014(1), 176843. <https://doi.org/10.1155/2014/176843>
- Frye, C. A. (2006). An overview of oral contraceptives. *Neurology*, 66(66_suppl_3), S29–S36. https://doi.org/10.1212/WNL.66.66_suppl_3.S29

- Gagnon, S. A., & Wagner, A. D. (2016). Acute stress and episodic memory retrieval: Neurobiological mechanisms and behavioral consequences. *Annals of the New York Academy of Sciences*, 1369(1), 55–75. <https://doi.org/10.1111/nyas.12996>
- Gaillard, A., Fehring, D. J., & Rossell, S. L. (2021). A systematic review and meta-analysis of behavioural sex differences in executive control. *European Journal of Neuroscience*, 53(2), 519–542. <https://doi.org/10.1111/ejn.14946>
- Galea, L. A. M., Frick, K. M., Hampson, E., Sohrabji, F., & Choleris, E. (2017). Why estrogens matter for behavior and brain health. *Neuroscience & Biobehavioral Reviews*. <https://doi.org/10.1016/j.neubiorev.2016.03.024>
- Garforth, B., Degnbol, H., Terris, E. T., Zak, P. J., & Winterdahl, M. (2020). Elevated plasma oxytocin levels and higher satisfaction with life in young oral contraceptive users. *Scientific Reports*, 10(1), Article 1. <https://doi.org/10.1038/s41598-020-64528-w>
- Gautier, R., Pinard, F., Vanneste, S., Fay, S., Bouazzaoui, B., & Taconnat, L. (2022). Aging, memory performance and metacognitive beliefs: A narrative review. *Gériatrie et Psychologie Neuropsychiatrie du Vieillissement*, 20(4), 497–505. <https://doi.org/10.1684/pnv.2022.1070>
- Geffen, G., Moar, K. J., O’hanlon, A. P., Clark, C. R., & Geffen, L. B. (1990). Performance measures of 16– to 86-year-old males and females on the auditory verbal learning test. *Clinical Neuropsychologist*, 4(1), 45–63. <https://doi.org/10.1080/13854049008401496>
- Genzel, L., Bäurle, A., Potyka, A., Wehrle, R., Adamczyk, M., Friess, E., Steiger, A., & Dresler, M. (2015). Diminished Nap Effects on Memory Consolidation Are Seen Under Oral Contraceptive Use. *Neuropsychobiology*, 70(4), 253–261. <https://doi.org/10.1159/000369022>
- Germine, L., Nakayama, K., Duchaine, B. C., Chabris, C. F., Chatterjee, G., & Wilmer, J. B. (2012). Is the Web as good as the lab? Comparable performance from Web and lab in

cognitive/perceptual experiments. *Psychonomic Bulletin & Review*, 19(5), 847–857.

<https://doi.org/10.3758/s13423-012-0296-9>

Gilewski, M. J., Zelinski, E. M., & Schaie, K. W. (1990). The Memory Functioning Questionnaire for assessment of memory complaints in adulthood and old age. *Psychology and Aging*, 5(4), 482–490. <https://doi.org/10.1037/0882-7974.5.4.482>

Gilfarb, R. A., Ranade, S., Smail, M., Wangler, L., Stewart, M., Rajesh, A., Lenz, K. M., & Leuner, B. (2025). Hormonal contraceptives during adolescence impact the female brain and behavior in a rat model. *Hormones and Behavior*, 171, 105725. <https://doi.org/10.1016/j.yhbeh.2025.105725>

Gillies, G. E., & McArthur, S. (2010). Estrogen actions in the brain and the basis for differential action in men and women: A case for sex-specific medicines. *Pharmacological Reviews*, 62(2), 155–198. <https://doi.org/10.1124/pr.109.002071>

Gingnell, M., Bannbers, E., Engman, J., Frick, A., Moby, L., Wikström, J., & Sundström-Poromaa, I. (2016). The effect of combined hormonal contraceptives use on brain reactivity during response inhibition. *The European Journal of Contraception & Reproductive Health Care*, 21(2), 150–157. <https://doi.org/10.3109/13625187.2015.1077381>

Gingnell, M., Engman, J., Frick, A., Moby, L., Wikström, J., Fredrikson, M., & Sundström-Poromaa, I. (2013). Oral contraceptive use changes brain activity and mood in women with previous negative affect on the pill—A double-blinded, placebo-controlled randomized trial of a levonorgestrel-containing combined oral contraceptive. *Psychoneuroendocrinology*, 38(7), 1133–1144. <https://doi.org/10.1016/j.psyneuen.2012.11.006>

Glisky, E. L., & Kong, L. L. (2008). Do Young and Older Adults Rely on Different Processes in Source Memory Tasks? A Neuropsychological Study. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, 34(4), 809–822. <https://doi.org/10.1037/0278-7393.34.4.809>

- Glisky, E. L., Polster, M. R., & Routhieaux, B. C. (1995). Double dissociation between item and source memory. *Neuropsychology*, 9(2), 229–235. <https://doi.org/10.1037/0894-4105.9.2.229>
- Glisky, E. L., Rubin, S. R., & Davidson, P. S. R. (2001). Source memory in older adults: An encoding or retrieval problem? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27(5), 1131–1146. <https://doi.org/10.1037/0278-7393.27.5.1131>
- Gogos, A. (2013). Natural and synthetic sex hormones: Effects on higher-order cognitive function and prepulse inhibition. *Biological Psychology*, 93(1), 17–23. <https://doi.org/10.1016/j.biopsycho.2013.02.001>
- Gogtay, N., Nugent III, T. F., Herman, D. H., Ordonez, A., Greenstein, D., Hayashi, K. M., Clasen, L., Toga, A. W., Giedd, J. N., Rapoport, J. L., & Thompson, P. M. (2006). Dynamic mapping of normal human hippocampal development. *Hippocampus*, 16(8), 664–672. <https://doi.org/10.1002/hipo.20193>
- Goldfarb, E. V. (2019). Enhancing memory with stress: Progress, challenges, and opportunities. *Brain and Cognition, Acute Stress, Memory and the Brain*, 133, 94–105. <https://doi.org/10.1016/j.bandc.2018.11.009>
- Golobof, A., & Kiley, J. (2016). The Current Status of Oral Contraceptives: Progress and Recent Innovations. *Seminars in Reproductive Medicine*, 34(3), 145–151. <https://doi.org/10.1055/s-0036-1572546>
- Gong, J., Harris, K., Peters, S., & Woodward, M. (2021). Reproductive factors and the risk of incident dementia: Results from the UK Biobank. *Alzheimer's & Dementia*, 17(S10), e049993. <https://doi.org/10.1002/alz.049993>
- González, M., Cabrera-Socorro, A., Pérez-García, C. G., Fraser, J. D., López, F. J., Alonso, R., & Meyer, G. (2007). Distribution patterns of estrogen receptor α and β in the human cortex and

hippocampus during development and adulthood. *Journal of Comparative Neurology*, 503(6), 790–802. <https://doi.org/10.1002/cne.21419>

Goodall, J., Fisher, C., Hetrick, S., Phillips, L., Parrish, E. M., & Allott, K. (2018). Neurocognitive Functioning in Depressed Young People: A Systematic Review and Meta-Analysis. *Neuropsychology Review*, 28(2), 216–231. <https://doi.org/10.1007/s11065-018-9373-9>

Gopi, Y., & Madan, C. R. (2023). EXPRESS: Subjective memory measures: Metamemory questionnaires currently in use. *Quarterly Journal of Experimental Psychology*, 77(5), 924–942. <https://doi.org/10.1177/17470218231183855>

Gordon, H. W., & Lee, P. A. (1993). No difference in cognitive performance between phases of the menstrual cycle. *Psychoneuroendocrinology*, 18(7), 521–531. [https://doi.org/10.1016/0306-4530\(93\)90045-M](https://doi.org/10.1016/0306-4530(93)90045-M)

Gosling, S. D., Rentfrow, P. J., & Swann, W. B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality*, 37(6), 504–528. [https://doi.org/10.1016/S0092-6566\(03\)00046-1](https://doi.org/10.1016/S0092-6566(03)00046-1)

Gravelsins, L., Duncan, K., & Einstein, G. (2021). Do oral contraceptives affect young women's memory? Dopamine-dependent working memory is influenced by COMT genotype, but not time of pill ingestion. *PLoS ONE*, 16(6), e0252807. <https://doi.org/10.1371/journal.pone.0252807>

Gregory, S., Booi, L., Jenkins, N., Bridgeman, K., Muniz-Terrera, G., & Farina, F. R. (2023). Hormonal contraception and risk for cognitive impairment or Alzheimer's disease and related dementias in young women: A scoping review of the evidence. *Frontiers in Global Women's Health*, 4. <https://doi.org/10.3389/fgwh.2023.1289096>

- Griksiene, R., Monciunskaitė, R., Arnatkeviciute, A., & Ruksenas, O. (2018). Does the use of hormonal contraceptives affect the mental rotation performance? *Hormones and Behavior*, 100, 29–38. <https://doi.org/10.1016/j.yhbeh.2018.03.004>
- Griksiene, R., & Ruksenas, O. (2011). Effects of hormonal contraceptives on mental rotation and verbal fluency. *Psychoneuroendocrinology*, 36(8), 1239–1248. <https://doi.org/10.1016/j.psyneuen.2011.03.001>
- Grissom, N. M., & Reyes, T. M. (2019). Let's call the whole thing off: Evaluating gender and sex differences in executive function. *Neuropsychopharmacology*, 44(1), Article 1. <https://doi.org/10.1038/s41386-018-0179-5>
- Guardia, T., Cote, K. A., Healey, M. K., Gammage, K. L., & Campbell, K. L. (2024). Self-reported physical activity and sleep quality is associated with working memory function in middle-aged and older adults during the COVID-19 pandemic. *Aging, Neuropsychology, and Cognition*, 1–20. <https://doi.org/10.1080/13825585.2024.2333066>
- Guerra, J. A., López-Muñoz, F., & Álamo, C. (2013). Progestins in Combined Contraceptives. *Journal of Experimental & Clinical Medicine*, 5(2), 51–55. <https://doi.org/10.1016/j.jecm.2013.02.007>
- Guo, P., Benito Ballesteros, A., Yeung, S. P., Liu, R., Saha, A., Curtis, L., Kaser, M., Haggard, M. P., & Cheke, L. G. (2022). COVCOG 2: Cognitive and memory deficits in long COVID: A second publication from the COVID and cognition study. *Frontiers in Aging Neuroscience*, 14, 804937. <https://doi.org/10.3389/fnagi.2022.804937>
- Gurvich, C., Hoy, K., Thomas, N., & Kulkarni, J. (2018). Sex Differences and the Influence of Sex Hormones on Cognition through Adulthood and the Aging Process. *Brain Sciences*, 8(9), Article 9. <https://doi.org/10.3390/brainsci8090163>

- Gurvich, C., Nicholls, I., Lavale, A., & Kulkarni, J. (2023). Oral contraceptives and cognition: A systematic review. *Frontiers in Neuroendocrinology*, 101052.
<https://doi.org/10.1016/j.yfrne.2022.101052>
- Gurvich, C., Warren, A. M., Worsley, R., Hudaib, A.-R., Thomas, N., & Kulkarni, J. (2020). Effects of Oral Contraceptive Androgenicity on Visuospatial and Social-Emotional Cognition: A Prospective Observational Trial. *Brain Sciences*, 10(4). <https://doi.org/10.3390/brainsci10040194>
- Haas, M., Scheibe, S., El Khawli, E., Künzi, M., Ihle, A., Ballhausen, N., Framorando, D., Kliegel, M., & Zuber, S. (2022). Online assessment of cognitive functioning across the adult lifespan using the eCOGTEL: A reliable alternative to laboratory testing. *European Journal of Ageing*, 19(3), 609–619. <https://doi.org/10.1007/s10433-021-00667-x>
- Haavisto, W., & Blaskewicz Boron, J. (2020). Contributions of personality and depressive symptoms on subjective and objective memory. *The International Journal of Aging and Human Development*, 90(1), 6–27. <https://doi.org/10.1177/0091415018822082>
- Hampson, E. (1990). Variations in sex-related cognitive abilities across the menstrual cycle. *Brain and Cognition*, 14(1), 26–43. [https://doi.org/10.1016/0278-2626\(90\)90058-V](https://doi.org/10.1016/0278-2626(90)90058-V)
- Hampson, E. (2002). Sex differences in human brain and cognition: The influence of sex steroids in early and adult life. In *Behavioral endocrinology*, 2nd ed (pp. 579–628). MIT Press.
- Hampson, E. (2018a). Estrogens and androgens in the prefrontal cortex: Relevance for cognition and decision-making. In *Routledge International Handbook of Social Neuroendocrinology*. Routledge.
- Hampson, E. (2018b). Regulation of cognitive function by androgens and estrogens. *Current Opinion in Behavioral Sciences, Sex and Gender*, 23, 49–57.
<https://doi.org/10.1016/j.cobeha.2018.03.002>

- Hampson, E. (2020). A brief guide to the menstrual cycle and oral contraceptive use for researchers in behavioral endocrinology. *Hormones and Behavior*, 119, 104655.
<https://doi.org/10.1016/j.yhbeh.2019.104655>
- Hampson, E. (2023). Oral contraceptives in the central nervous system: Basic pharmacology, methodological considerations, and current state of the field. *Frontiers in Neuroendocrinology*, 68, 101040. <https://doi.org/10.1016/j.yfrne.2022.101040>
- Hampson, E. (2025). Do combined oral contraceptives have long-term effects? Little evidence of an enduring effect on cognitive function in former users. *Hormones and Behavior*, 174, 105800.
<https://doi.org/10.1016/j.yhbeh.2025.105800>
- Hampson, E., Abrahamson, S. N., Breddy, T. N., Iqbal, M., & Wolff, E. R. (2024). Current oral contraceptive use affects explicit and implicit measures of depression in women. *Frontiers in Psychology*, 15. <https://doi.org/10.3389/fpsyg.2024.1462891>
- Hampson, E., & Morley, E. E. (2013). Estradiol concentrations and working memory performance in women of reproductive age. *Psychoneuroendocrinology*, 38(12), 2897–2904.
<https://doi.org/10.1016/j.psyneuen.2013.07.020>
- Hampson, E., Morley, E. E., Evans, K. L., & Fleury, C. (2022). Effects of oral contraceptives on spatial cognition depend on pharmacological properties and phase of the contraceptive cycle. *Frontiers in Endocrinology*, 13. <https://doi.org/10.3389/fendo.2022.888510>
- Hara, Y., Waters, E. M., McEwen, B. S., & Morrison, J. H. (2015). Estrogen Effects on Cognitive and Synaptic Health Over the Lifecourse. *Physiological Reviews*, 95(3), 785–807.
<https://doi.org/10.1152/physrev.00036.2014>

- Harrington, D. (2008). Requirements for conducting confirmatory factor analysis: Data considerations. In D. Harrington (Ed.), *Confirmatory factor analysis* (pp. 36–49). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780195339888.003.0003>
- Hatta, T., & Nagaya, K. (2009). Menstrual Cycle Phase Effects on Memory and Stroop Task Performance. *Archives of Sexual Behavior*, 38(5), 821. <https://doi.org/10.1007/s10508-008-9445-7>
- Heller, C., Güllmar, D., Colic, L., Pritschet, L., Gell, M., Javaheripour, N., de la Cruz, F., Rojczyk, P., Koeppel, C. J., Larsen, B., Ganjgahi, H., Lange, F. J., Buck, A.-C., Jesgarzewsky, T. L., Dahnke, R., Kiehnopf, M., Jacobs, E. G., Kikinis, Z., Walter, M., ... Gaser, C. (2025). Hormonal milieu influences whole-brain structural dynamics across the menstrual cycle using dense sampling in multiple individuals. *Nature Neuroscience*, 1–13. <https://doi.org/10.1038/s41593-025-02066-2>
- Heller, C., Güllmar, D., Koeppel, C. J., Rojczyk, P., Stein, H., Taylor, C. M., Jacobs, E. G., Derntl, B., Kikinis, Z., Walter, M., & Croy, I. (2024). Hippocampal volume and affect in response to fluctuating estrogens in menstrual cycle irregularity: A longitudinal single-subject study. *Npj Women's Health*, 2(1), 1–9. <https://doi.org/10.1038/s44294-024-00023-1>
- Heller, C., Kimmig, A.-C. S., Kubicki, M. R., Derntl, B., & Kikinis, Z. (2022). Imaging the human brain on oral contraceptives: A review of structural imaging methods and implications for future research goals. *Frontiers in Neuroendocrinology*, 67, 101031. <https://doi.org/10.1016/j.yfrne.2022.101031>
- Herlitz, A., & Lovén, J. (2013). Sex differences and the own-gender bias in face recognition: A meta-analytic review. *Visual Cognition*, 21(9–10), 1306–1336. <https://doi.org/10.1080/13506285.2013.823140>

- Herlitz, A., & Rehnman, J. (2008). Sex Differences in Episodic Memory. *Current Directions in Psychological Science*, 17(1), 52–56. <https://doi.org/10.1111/j.1467-8721.2008.00547.x>
- Herrera, E., Pérez-Sánchez, M. d. C., San Miguel-Abella, R., Barrenechea, A., Blanco, C., Solares, L., González, L., Iza, C., Castro, I., Nicolás, E., Sierra, D., Suárez, P., & González-Nosti, M. (2023). Cognitive impairment in young adults with post COVID-19 syndrome. *Scientific Reports*, 13(1), 6378. <https://doi.org/10.1038/s41598-023-32939-0>
- Herrera, A. Y., Velasco, R., Faude, S., White, J. D., Opitz, P. C., Huang, R., Tu, K., & Mather, M. (2020). Brain activity during a post-stress working memory task differs between the hormone-present and hormone-absent phase of hormonal contraception. *Neurobiology of Stress*, 13, 100248. <https://doi.org/10.1016/j.ynstr.2020.100248>
- Hertel, J., König, J., Homuth, G., Van der Auwera, S., Wittfeld, K., Pietzner, M., Kacprowski, T., Pfeiffer, L., Kretschmer, A., Waldenberger, M., Kastenmüller, G., Artati, A., Suhre, K., Adamski, J., Langner, S., Völker, U., Völzke, H., Nauck, M., Friedrich, N., & Grabe, H. J. (2017). Evidence for Stress-like Alterations in the HPA-Axis in Women Taking Oral Contraceptives. *Scientific Reports*, 7(1), 14111. <https://doi.org/10.1038/s41598-017-13927-7>
- Hertzog, C., & Curley, T. (2018). Metamemory and cognitive aging. In *Oxford research encyclopedia of psychology*. <https://doi.org/10.1093/acrefore/9780190236557.013.377>
- Hertzog, C., & Pearman, A. (2013). Memory complaints in adulthood and old age. In T. Perfect & D. S. Lindsay (Eds.), *The SAGE handbook of applied memory* (pp. 423–443). Sage.
- Hertzog, C., Small, B. J., McFall, G. P., & Dixon, R. A. (2019). Age, cohort, and period effects on metamemory beliefs. *Psychology and Aging*, 34(8), 1077–1089. <https://doi.org/10.1037/pag0000384>

- Hill, P. L., Pfund, G. N., Cruitt, P. J., Spears, I., Norton, S. A., Bogdan, R., & Oltmanns, T. F. (2024). Personality traits moderate associations between word recall and subjective memory. *Aging, Neuropsychology, and Cognition*, 31(4), 705–722.
<https://doi.org/10.1080/13825585.2023.2249195>
- Hilz, E. N. (2022). Methods and considerations for the use of hormonal contraceptives in rat models of neurobehavior. *Frontiers in Neuroendocrinology*, 66, 101011.
<https://doi.org/10.1016/j.yfrne.2022.101011>
- Hirnstien, M., Stuebs, J., Moè, A., & Hausmann, M. (2023). Sex/Gender Differences in Verbal Fluency and Verbal-Episodic Memory: A Meta-Analysis. *Perspectives on Psychological Science*, 18(1), 67–90. <https://doi.org/10.1177/17456916221082116>
- Hochheim, M. C., Frokjaer, V. G., Larsen, S. V., & Dam, V. H. (2025). Effect of combined oral contraceptive use on verbal memory function in healthy women. *Archives of Women's Mental Health*, 1–9. <https://doi.org/10.1007/s00737-025-01592-z>
- Hodgetts, S., Hausmann, M., & Weis, S. (2015). High estradiol levels improve false memory rates and meta-memory in highly schizotypal women. *Psychiatry Research*, 229(3), 708–714.
<https://doi.org/10.1016/j.psychres.2015.08.016>
- Hogervorst, E., Williams, J., Budge, M., Riedel, W., & Jolles, J. (2000). The nature of the effect of female gonadal hormone replacement therapy on cognitive function in post-menopausal women: A meta-analysis. *Neuroscience*, 101(3), 485–512. [https://doi.org/10.1016/S0306-4522\(00\)00410-3](https://doi.org/10.1016/S0306-4522(00)00410-3)
- Hülür, G., Hertzog, C., Pearman, A. M., & Gerstorf, D. (2015). Correlates and moderators of change in subjective memory and memory performance: Findings from the health and retirement study. *Gerontology*, 61(3), 232–240. <https://doi.org/10.1159/000369010>

- Hussain, D., Hanafi, S., Konishi, K., Brake, W. G., & Bohbot, V. D. (2016). Modulation of spatial and response strategies by phase of the menstrual cycle in women tested in a virtual navigation task. *Psychoneuroendocrinology*, 70, 108–117. <https://doi.org/10.1016/j.psyneuen.2016.05.008>
- Illman, N. A., Moulin, C. J. A., & Kemp, S. (2015). Assessment of everyday memory functioning in temporal lobe epilepsy and healthy adults using the multifactorial memory questionnaire (MMQ). *Epilepsy Research*, 113, 86–89. <https://doi.org/10.1016/j.eplepsyres.2015.03.011>
- Islam, F., Sparkes, C., Roodenrys, S., & Astheimer, L. (2008). Short-term changes in endogenous estrogen levels and consumption of soy isoflavones affect working and verbal memory in young adult females. *Nutritional Neuroscience*, 11(6), 251–262. <https://doi.org/10.1179/147683008X301612>
- Isquith, P. K., Roth, R. M., & Gioia, G. (2013). Contribution of Rating Scales to the Assessment of Executive Functions. *Applied Neuropsychology: Child*, 2(2), 125–132. <https://doi.org/10.1080/21622965.2013.748389>
- Jacobs, E., & D'Esposito, M. (2011). Estrogen Shapes Dopamine-Dependent Cognitive Processes: Implications for Women's Health. *Journal of Neuroscience*, 31(14), 5286–5293. <https://doi.org/10.1523/JNEUROSCI.6394-10.2011>
- Jensen, A., Carton, S., Ardilliez, O., Hu, R., & Davidson, P. S. R. (2025). An online, updated battery for episodic memory and executive control composites in older adults. *Journal of Clinical and Experimental Neuropsychology*, 47(5), 436–456. <https://doi.org/10.1080/13803395.2025.2544730>
- Jensen, A., Castro, A. W., Hu, R., Drouin, H., Rabipour, S., Bégin-Galarneau, M. È., ... & Davidson, P. S. (2024). Multifactorial memory questionnaire: a comparison of young and older adults. *Memory*, 32(8), 1043-1056. <https://doi.org/10.1080/09658211.2024.2378870>

- Jensen, A., Thériault, K., Yilmaz, E., Pon, E., & Davidson, P. S. R. (2023). Mental rotation, episodic memory, and executive control: Possible effects of biological sex and oral contraceptive use. *Neurobiology of Learning and Memory*, 198, 107720. <https://doi.org/10.1016/j.nlm.2023.107720>
- Jentsch, V. L., Pötzl, L., Wolf, O. T., & Merz, C. J. (2022). Hormonal contraceptive usage influences stress hormone effects on cognition and emotion. *Frontiers in Neuroendocrinology*, 67, 101012. <https://doi.org/10.1016/j.yfrne.2022.101012>
- Jeryous Fares, B., & Taler, V. (2026). Investigating the effects of second language background, proficiency, and usage on episodic memory in middle-aged and older adults. *Canadian Journal of Experimental Psychology / Revue Canadienne de Psychologie Expérimentale*, 80(1), 1–9. <https://doi.org/10.1037/cep0000391>
- Jeyakumar, M., Carlson, K. E., Gunther, J. R., & Katzenellenbogen, J. A. (2011). Exploration of Dimensions of Estrogen Potency: PARSING LIGAND BINDING AND COACTIVATOR BINDING AFFINITIES *. *Journal of Biological Chemistry*, 286(15), 12971–12982. <https://doi.org/10.1074/jbc.M110.205112>
- Jiang, G., Mai, Y., & Yuan, K.-H. (2017). Advances in measurement invariance and mean comparison of latent variables: Equivalence testing and a projection-based approach. *Frontiers in Psychology*, 8. <https://www.frontiersin.org/articles/10.3389/fpsyg.2017.01823>
- Johansson, T., Larsen, S. V., Bui, M., Ek, W. E., Karlsson, T., & Johansson, Å. (2023). Population-based cohort study of oral contraceptive use and risk of depression. *Epidemiology and Psychiatric Sciences*, 32, e39. <https://doi.org/10.1017/S2045796023000525>
- Jonker, C., Geerlings, M. I., & Schmand, B. (2000). Are memory complaints predictive for dementia? A review of clinical and population-based studies. *International Journal of Geriatric Psychiatry*,

15(11), 983–991. [https://doi.org/10.1002/1099-1166\(200011\)15:11<983::AID-GPS238>3.0.CO;2-5](https://doi.org/10.1002/1099-1166(200011)15:11<983::AID-GPS238>3.0.CO;2-5)

Karim, R., Dang, H., Henderson, V. W., Hodis, H. N., St. John, J., Brinton, R. D., & Mack, W. J.

(2016). Effect of Reproductive History and Exogenous Hormone Use on Cognitive Function in Mid- and Late Life. *Journal of the American Geriatrics Society*, 64(12), 2448–2456.

<https://doi.org/10.1111/jgs.14658>

Karr, J. E. (2022). Compensatory cognitive strategy use by young adults: A psychometric evaluation of self-report measures. *Assessment*, 29(3), 441–454. <https://doi.org/10.1177/1073191120981769>

Keyes, K. M., Cheslack-Postava, K., Westhoff, C., Heim, C. M., Haloossim, M., Walsh, K., &

Koenen, K. (2013). Association of Hormonal Contraceptive Use With Reduced Levels of Depressive Symptoms: A National Study of Sexually Active Women in the United States.

American Journal of Epidemiology, 178(9), 1378–1388. <https://doi.org/10.1093/aje/kwt188>

Kinzer, A., & Suhr, J. A. (2016). Dementia worry and its relationship to dementia exposure, psychological factors, and subjective memory concerns. *Applied Neuropsychology: Adult*, 23(3), 196–204. <https://doi.org/10.1080/23279095.2015.1030669>

Kirschbaum, C., Kudielka, B. M., Gaab, J., Schommer, N. C., & Hellhammer, D. H. (1999). Impact of Gender, Menstrual Cycle Phase, and Oral Contraceptives on the Activity of the Hypothalamus-Pituitary-Adrenal Axis. *Psychosomatic Medicine*, 61(2), 154–162.

Kochan, N. A., Heffernan, M., Valenzuela, M., Sachdev, P. S., Lam, B. C. P., Fiatarone Singh, M., Anstey, K. J., Chau, T., & Brodaty, H. (2022). Reliability, Validity, and User-Experience of Remote Unsupervised Computerized Neuropsychological Assessments in Community-Living 55- to 75-Year-Olds. *Journal of Alzheimer's Disease*, 90(4), 1629–1645. <https://doi.org/10.3233/JAD-220665>

- Koebele, S. V., & Bimonte-Nelson, H. A. (2017). The endocrine-brain-aging triad where many paths meet: Female reproductive hormone changes at midlife and their influence on circuits important for learning and memory. *Experimental Gerontology*, 94, 14–23.
<https://doi.org/10.1016/j.exger.2016.12.011>
- Koebele, S. V., Poisson, M. L., Palmer, J. M., Berns-Leone, C., Northup-Smith, S. N., Peña, V. L., Strouse, I. M., Bulen, H. L., Patel, S., Croft, C., & Bimonte-Nelson, H. A. (2022). Evaluating the Cognitive Impacts of Drospirenone, a Spironolactone-Derived Progestin, Independently and in Combination With Ethinyl Estradiol in Ovariectomized Adult Rats. *Frontiers in Neuroscience*, 16. <https://doi.org/10.3389/fnins.2022.885321>
- Kowalczyk, M., Kornacka, M., Wisiecka, K., Młyniec, A., Redel, A., Szwykowska-Ziemniak, M., & Krejtz, I. (2023). The Relationship Between the Menstrual Cycle, Oral Contraceptives, and Executive Function – Inhibition, Updating, and Shifting. *European Psychologist*. (world).
<https://econtent.hogrefe.com/doi/10.1027/1016-9040/a000514>
- Kraft, M. Z., Rojczyk, P., Weiss, T., Derntl, B., Kikinis, Z., Croy, I., & Heller, C. (2024). Symptoms of mental disorders and oral contraception use: A systematic review and meta-analysis. *Frontiers in Neuroendocrinology*, 72, 101111. <https://doi.org/10.1016/j.yfrne.2023.101111>
- Kramer, J. H., Delis, D. C., & Daniel, M. (1988). Sex differences in verbal learning. *Journal of Clinical Psychology*, 44(6), 907–915. [https://doi.org/10.1002/1097-4679\(198811\)44:6<907::AID-JCLP2270440610>3.0.CO;2-8](https://doi.org/10.1002/1097-4679(198811)44:6<907::AID-JCLP2270440610>3.0.CO;2-8)
- Krynicky, C. R., Hacker, D., & Jones, C. A. (2023). An evaluation of the convergent validity of a face-to-face and virtual neuropsychological assessment counter balanced. *Journal of Neuropsychology*, 17(2), 319–334. <https://doi.org/10.1111/jnp.12300>

- Ku, Y.-T., Chiu, P.-Y., Hua, M.-S., Liao, Y.-C., & Chang, H.-T. (2023). Development of a revised version of subjective memory complaints questionnaire in Taiwan: A preliminary study. *Archives of Clinical Neuropsychology*, 39(1), 78–91. <https://doi.org/10.1093/arclin/acad045>
- Kuhl, H. (1996). Comparative Pharmacology of Newer Progestogens. *Drugs*, 51(2), 188–215. <https://doi.org/10.2165/00003495-199651020-00002>
- Kuhlmann, S., & Wolf, O. T. (2005). Cortisol and memory retrieval in women: Influence of menstrual cycle and oral contraceptives. *Psychopharmacology*, 183(1), 65–71. <https://doi.org/10.1007/s00213-005-0143-z>
- Kulkarni, J. (2007). Depression as a side effect of the contraceptive pill. *Expert Opinion on Drug Safety*, 6(4), 371–374. <https://doi.org/10.1517/14740338.6.4.371>
- Kurshan, N., & Epperson, C. (2006). Oral contraceptives and mood in women with and without premenstrual dysphoria: A theoretical model. *Archives of Women's Mental Health*, 9(1), 1–14. <https://doi.org/10.1007/s00737-005-0102-z>
- Lacasse, J. M., Gomez-Perales, E., & Brake, W. G. (2022). Modeling hormonal contraception in female rats: A framework for studies in behavioral neurobiology. *Frontiers in Neuroendocrinology*, 67, 101020. <https://doi.org/10.1016/j.yfrne.2022.101020>
- Lacasse, J. M., Heller, C., Kheloui, S., Ismail, N., Raval, A. P., Schuh, K. M., Tronson, N. C., & Leuner, B. (2024). Beyond Birth Control: The Neuroscience of Hormonal Contraceptives. *Journal of Neuroscience*, 44(40). <https://doi.org/10.1523/JNEUROSCI.1235-24.2024>
- Lacasse, J. M., Ismail, N., Porcu, P., & Raval, A. P. (2025). Animal models of hormonal contraceptives: Understanding drug-specific and user-specific variables. *Journal of Neuroendocrinology*, 37(7), e13500. <https://doi.org/10.1111/jne.13500>

Lagunas, N., Sánchez-Giraldo, L., Grassi, D., Diéguez-Risco, T., & de la Torre-Luque, A. (2026).

Differences in verbal memory, visuospatial ability and cognitive inhibition among young women using drospirenone and ethinyl oestradiol oral contraceptives versus naturally cycling controls.

Acta Neuropsychiatrica, 38, e9. <https://doi.org/10.1017/neu.2025.10053>

Laird, S., Ney, L. J., Felmingham, K. L., & Gogos, A. (2019). Hormonal Contraception and the Brain:

Examining Cognition and Psychiatric Disorders. *Current Psychiatry Research and Reviews*,

15(2), 116–131. <https://doi.org/10.2174/1573400515666190521113841>

Le, J., Thomas, N., & Gurvich, C. (2020). Cognition, The Menstrual Cycle, and Premenstrual

Disorders: A Review. *Brain Sciences*, 10(4). <https://doi.org/10.3390/brainsci10040198>

Lenroot, R. K., & Giedd, J. N. (2006). Brain development in children and adolescents: Insights from

anatomical magnetic resonance imaging. *Neuroscience & Biobehavioral Reviews*,

Methodological and Conceptual Advances in the Study of Brain-Behavior Dynamics: A

Multivariate Lifespan Perspective, 30(6), 718–729.

<https://doi.org/10.1016/j.neubiorev.2006.06.001>

Leong, N.-W. (Ivy), Barnard, M., Rosenthal, M., & Holmes, E. (2026). Oral Contraceptive

Knowledge Among Adolescents and Young Women. *Pharmacy*, 14(1), 30.

<https://doi.org/10.3390/pharmacy14010030>

Leong, V., Raheel, K., Sim, J. Y., Kacker, K., Karlaftis, V. M., Vassiliu, C., Kalaivanan, K., Chen, S.

H. A., Robbins, T. W., Sahakian, B. J., & Kourtzi, Z. (2022). A New Remote Guided Method for

Supervised Web-Based Cognitive Testing to Ensure High-Quality Data: Development and

Usability Study. *Journal of Medical Internet Research*, 24(1), e28368.

<https://doi.org/10.2196/28368>

- Leranth, C., Hajszan, T., Szigeti-Buck, K., Bober, J., & MacLusky, N. J. (2008). Bisphenol A prevents the synaptogenic response to estradiol in hippocampus and prefrontal cortex of ovariectomized nonhuman primates. *Proceedings of the National Academy of Sciences of the United States of America*, 105(37), Article 37. <https://doi.org/10.1073/pnas.0806139105>
- Lewin, C., Wolgers, G., & Herlitz, A. (2001). Sex differences favoring women in verbal but not in visuospatial episodic memory. *Neuropsychology*, 15(2), 165–173. <https://doi.org/10.1037/0894-4105.15.2.165>
- Lindh, I., Hognert, H., & Milsom, I. (2016). The changing pattern of contraceptive use and pregnancies in four generations of young women. *Acta Obstetrica et Gynecologica Scandinavica*, 95(11), 1264–1272. <https://doi.org/10.1111/aogs.13003>
- Lindseth, L. R. S., de Lange, A.-M. G., van der Meer, D., Agartz, I., Westlye, L. T., Tamnes, C. K., & Barth, C. (2023). Associations between reproductive history, hormone use, APOE ε4 genotype and cognition in middle- to older-aged women from the UK Biobank. *Frontiers in Aging Neuroscience*, 14. <https://doi.org/10.3389/fnagi.2022.1014605>
- Ling, J., Sun, W., Chan, N. Y., Zhang, J., Lam, S. P., Li, A. M., Chan, J. W. Y., Kyle, S. D., & Li, S. X. (2020). Effects of insomnia symptoms and objective short sleep duration on memory performance in youths. *Journal of Sleep Research*, 29(4), e13049. <https://doi.org/10.1111/jsr.13049>
- Lisofsky, N., Mårtensson, J., Eckert, A., Lindenberger, U., Gallinat, J., & Kühn, S. (2015). Hippocampal volume and functional connectivity changes during the female menstrual cycle. *NeuroImage*, 118, 154–162. <https://doi.org/10.1016/j.neuroimage.2015.06.012>

- Lisofsky, N., Riediger, M., Gallinat, J., Lindenberger, U., & Kühn, S. (2016). Hormonal contraceptive use is associated with neural and affective changes in healthy young women. *NeuroImage*, 134, 597–606. <https://doi.org/10.1016/j.neuroimage.2016.04.042>
- Liu, H., Yao, J., Wang, W., & Zhang, D. (2017). Association between duration of oral contraceptive use and risk of hypertension: A meta-analysis. *The Journal of Clinical Hypertension*, 19(10), 1032–1041. <https://doi.org/10.1111/jch.13042>
- Loprinzi, P. D. (2019). Interrelationships between depression, exercise and subjective memory complaints. *Revue Neurologique*, 175(5), 319–323. <https://doi.org/10.1016/j.neurol.2018.10.006>
- Luine, V., & Frankfurt, M. (2013). Interactions between estradiol, BDNF and dendritic spines in promoting memory. *Neuroscience, Steroid Hormone Actions in the CNS: The Role of Brain-Derived Neurotrophic Factor (BDNF)*, 239, 34–45.
<https://doi.org/10.1016/j.neuroscience.2012.10.019>
- Luine, V. N. (2014). Estradiol and cognitive function: Past, present and future. *Hormones and Behavior*, 66(4), 602–618. <https://doi.org/10.1016/j.yhbeh.2014.08.011>
- Lundin, C., Danielsson, K. G., Bixo, M., Moby, L., Bengtsdotter, H., Jawad, I., Marions, L., Brynhildsen, J., Malmborg, A., Lindh, I., & Sundström Poromaa, I. (2017). Combined oral contraceptive use is associated with both improvement and worsening of mood in the different phases of the treatment cycle—A double-blind, placebo-controlled randomized trial. *Psychoneuroendocrinology*, 76, 135–143. <https://doi.org/10.1016/j.psyneuen.2016.11.033>
- Lundin, C., Wikman, A., Lampa, E., Bixo, M., Gemzell-Danielsson, K., Wikman, P., Ljung, R., & Sundström Poromaa, I. (2022). There is no association between combined oral hormonal contraceptives and depression: A Swedish register-based cohort study. *BJOG: An International*

Journal of Obstetrics & Gynaecology, 129(6), 917–925. <https://doi.org/10.1111/1471-0528.17028>

Lyons, S., Arcara, J., Deardorff, J., & Gomez, A. M. (2019). Financial Strain and Contraceptive Use Among Women in the United States: Differential Effects by Age. *Women's Health Issues*, 29(2), 153–160. <https://doi.org/10.1016/j.whi.2018.12.006>

Mac Giolla, E., & Kajonius, P. J. (2019). Sex differences in personality are larger in gender equal countries: Replicating and extending a surprising finding. *International Journal of Psychology*, 54(6), 705–711. <https://doi.org/10.1002/ijop.12529>

MacPherson, S. E., Sala, S. D., Cox, S. R., Girardi, A., & Iveson, M. H. (2015). *Handbook of Frontal Lobe Assessment*. Oxford University Press.

Mahon, S., Webb, J., Snell, D., & Theadom, A. (2022). Feasibility of administering the WAIS-IV using a home-based telehealth videoconferencing model. *The Clinical Neuropsychologist*, 36(3), 558–570. <https://doi.org/10.1080/13854046.2021.1985172>

Maki, P. M., Rich, J. B., & Shayna Rosenbaum, R. (2002). Implicit memory varies across the menstrual cycle: Estrogen effects in young women. *Neuropsychologia*, 40(5), 518–529. [https://doi.org/10.1016/S0028-3932\(01\)00126-9](https://doi.org/10.1016/S0028-3932(01)00126-9)

Malek-Ahmadi, M., Powell, J. J., Belden, C. M., Connor, K., Evans, L., Coon, D. W., & Nieri, W. (2015). Age- and education-adjusted normative data for the montreal cognitive assessment (MoCA) in older adults age 70–99. *Aging, Neuropsychology, and Cognition*, 22(6), 755–761. <https://doi.org/10.1080/13825585.2015.1041449>

Marecková, K., Perrin, J. S., Nawaz Khan, I., Lawrence, C., Dickie, E., McQuiggan, D. A., Paus, T., IMAGEN Consortium, & Desrivieres, S. (2014). Hormonal contraceptives, menstrual cycle and

brain response to faces. *Social Cognitive and Affective Neuroscience*, 9(2), 191–200.

<https://doi.org/10.1093/scan/nss128>

Masama, C., Jarkas, D. A., Thaw, E., Daneshmend, A. Z. B., Franklyn, S. I., Beaurepaire, C., & McQuaid, R. J. (2022). Hormone contraceptive use in young women: Altered mood states, neuroendocrine and inflammatory biomarkers. *Hormones and Behavior*, 144, 105229.

<https://doi.org/10.1016/j.yhbeh.2022.105229>

McCabe, D. P., Roediger, H. L., McDaniel, M. A., Balota, D. A., & Hambrick, D. Z. (2010). The Relationship Between Working Memory Capacity and Executive Functioning: Evidence for a Common Executive Attention Construct. *Neuropsychology*, 24(2), 222–243.

<https://doi.org/10.1037/a0017619>

McDonough, I. M., McDougall, G. J., LaRocca, M., Dalmida, S. G., & Arheart, K. L. (2020). Refining the metamemory in adulthood questionnaire: A 20-item version of change and capacity designed for research and clinical settings. *Aging & Mental Health*, 24(7), 1054–1063.

<https://doi.org/10.1080/13607863.2019.1594160>

McEwen, B. S., Akama, K. T., Spencer-Segal, J. L., Milner, T. A., & Waters, E. M. (2012). Estrogen effects on the brain: Actions beyond the hypothalamus via novel mechanisms. *Behavioral Neuroscience*, 126(1), 4–16. <https://doi.org/10.1037/a0026708>

McEwen, B. S., & Alves, S. E. (1999). Estrogen actions in the central nervous system. *Endocrine Reviews*, 20(3), 279–307. <https://doi.org/10.1210/edrv.20.3.0365>

McEwen, B. S., & Milner, T. A. (2017). Understanding the broad influence of sex hormones and sex differences in the brain. *Journal of Neuroscience Research*, 95(1–2), 24–39.

<https://doi.org/10.1002/jnr.23809>

- McEwen, B. S., & Woolley, C. S. (1994). Estradiol and progesterone regulate neuronal structure and synaptic connectivity in adult as well as developing brain. *Experimental Gerontology, Special Issue Proceedings of a Conference on Menopause: Current Knowledge and Recommendations for Research*, 29(3), 431–436. [https://doi.org/10.1016/0531-5565\(94\)90022-1](https://doi.org/10.1016/0531-5565(94)90022-1)
- McKetta, S., & Keyes, K. M. (2019). Oral contraceptive use and depression among adolescents. *Annals of Epidemiology*, 29, 46–51. <https://doi.org/10.1016/j.annepidem.2018.10.002>
- McLean, C. P., Asnaani, A., Litz, B. T., & Hofmann, S. G. (2011). Gender differences in anxiety disorders: Prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research*, 45(8), 1027–1035. <https://doi.org/10.1016/j.jpsychires.2011.03.006>
- Mendes, T., Ginó, S., Ribeiro, F., Guerreiro, M., de Sousa, G., Ritchie, K., & de Mendonça, A. (2008). Memory complaints in healthy young and elderly adults: Reliability of memory reporting. *Aging & Mental Health*, 12(2), 177–182. <https://doi.org/10.1080/13607860701797281>
- Mennenga, S. E., Gerson, J. E., Koebele, S. V., Kingston, M. L., Tsang, C. W. S., Engler-Chiurazzi, E. B., Baxter, L. C., & Bimonte-Nelson, H. A. (2015). Understanding the cognitive impact of the contraceptive estrogen Ethinyl Estradiol: Tonic and cyclic administration impairs memory, and performance correlates with basal forebrain cholinergic system integrity. *Psychoneuroendocrinology*, 54, 1–13. <https://doi.org/10.1016/j.psyneuen.2015.01.002>
- Menting-Henry, S., Hidalgo-Lopez, E., Aichhorn, M., Kronbichler, M., Kerschbaum, H., & Pletzer, B. (2022). Oral Contraceptives Modulate the Relationship Between Resting Brain Activity, Amygdala Connectivity and Emotion Recognition – A Resting State fMRI Study. *Frontiers in Behavioral Neuroscience*, 16. <https://www.frontiersin.org/articles/10.3389/fnbeh.2022.775796>
- Merz, C. J. (2017). Contribution of stress and sex hormones to memory encoding. *Psychoneuroendocrinology*, 82, 51–58. <https://doi.org/10.1016/j.psyneuen.2017.05.002>

Mielke, M. M., Vemuri, P., & Rocca, W. A. (2014). Clinical epidemiology of Alzheimer's disease: Assessing sex and gender differences. *Clinical Epidemiology*, 6, 37–48.

<https://doi.org/10.2147/CLEP.S37929>

Mihalik, J. P., Ondrak, K. S., Guskiewicz, K. M., & McMurray, R. G. (2009). The effects of menstrual cycle phase on clinical measures of concussion in healthy college-aged females. *Journal of Science and Medicine in Sport*, 12(3), 383–387.

<https://doi.org/10.1016/j.jsams.2008.05.003>

Mihalj, M., Drenjančević, I., Včev, A., Šumanovac, A., Čavka, A., Vladetić, M., & Gmajnić, R. (2014). Basic cognitive functions across the menstrual cycle in a controlled female cohort. *Medicinski Glasnik: Official Publication of the Medical Association of Zenica-Doboj Canton, Bosnia and Herzegovina*, 11(1), 177–185.

Mitchell, V. E., & Welling, L. L. M. (2020). Not All Progestins are Created Equally: Considering Unique Progestins Individually in Psychobehavioral Research. *Adaptive Human Behavior and Physiology*, 6(3), 381–412. <https://doi.org/10.1007/s40750-020-00137-1>

Mogle, J., Hill, N. L., Bhargava, S., Bell, T. R., & Bhang, I. (2020). Memory complaints and depressive symptoms over time: A construct-level replication analysis. *BMC Geriatrics*, 20(1), 57. <https://doi.org/10.1186/s12877-020-1451-1>

Mogle, J., Turner, J. R., Bhargava, S., Stawski, R. S., Almeida, D. M., & Hill, N. L. (2023). Individual differences in frequency and impact of daily memory lapses: Results from a national lifespan sample. *BMC Geriatrics*, 23, 670. <https://doi.org/10.1186/s12877-023-04363-6>

Mol, M., Carpay, M., Ramakers, I., Rozendaal, N., Verhey, F., & Jolles, J. (2007). The effect of perceived forgetfulness on quality of life in older adults; a qualitative review. *International Journal of Geriatric Psychiatry*, 22(5), 393–400. <https://doi.org/10.1002/gps.1686>

- Mol, M. E. M., Ruiter, R. A. C., Verhey, F. R. J., Dijkstra, J., & Jolles, J. (2008). A study into the psychosocial determinants of perceived forgetfulness: Implications for future interventions. *Aging & Mental Health, 12*(2), 167–176. <https://doi.org/10.1080/13607860801972503>
- Montenegro Peña, M., Llanero Luque, M., Huertas Hoyas, E., Claver Martín, M. D., Montejo Carrasco, P., De Andrés Montes, M. E., Reinoso García, A. I., & García Marín, A. (2013). Relación de las quejas de memoria con el rendimiento de memoria, el estado de ánimo y variables sociodemográficas en adultos jóvenes. *Revista de neurología, 57*(9), 396–404. <https://doi.org/10.33588/rn.5709.2013047>
- Montoya, E. R., & Bos, P. A. (2017). How Oral Contraceptives Impact Social-Emotional Behavior and Brain Function. *Trends in Cognitive Sciences, 21*(2), 125–136. <https://doi.org/10.1016/j.tics.2016.11.005>
- Mordecai, K. L., Rubin, L. H., Eatough, E., Sundermann, E., Drogos, L., Savarese, A., & Maki, P. M. (2017). Cortisol reactivity and emotional memory after psychosocial stress in oral contraceptive users. *Journal of Neuroscience Research, 95*(1–2), 126–135. <https://doi.org/10.1002/jnr.23904>
- Mordecai, K. L., Rubin, L. H., & Maki, P. M. (2008). Effects of menstrual cycle phase and oral contraceptive use on verbal memory. *Hormones and Behavior, 54*(2), 286–293. <https://doi.org/10.1016/j.yhbeh.2008.03.006>
- Morgan, M., J. Rapkin, A., D'Elia, L., Reading, A., & Goldman, L. (1996). Cognitive functioning in premenstrual syndrome. *Obstetrics & Gynecology, 88*(6), 961–966. [https://doi.org/10.1016/S0029-7844\(96\)00362-6](https://doi.org/10.1016/S0029-7844(96)00362-6)
- Morgan, M., & Rapkin, A. (2002). Cognitive flexibility, reaction time, and attention in women with premenstrual dysphoric disorder. *The Journal of Gender-Specific Medicine, 5*(3), 28–36.

- Mumford, S. L., Steiner, A. Z., Pollack, A. Z., Perkins, N. J., Filiberto, A. C., Albert, P. S., Mattison, D. R., Wactawski-Wende, J., & Schisterman, E. F. (2012). The Utility of Menstrual Cycle Length as an Indicator of Cumulative Hormonal Exposure. *The Journal of Clinical Endocrinology & Metabolism*, 97(10), E1871–E1879. <https://doi.org/10.1210/jc.2012-1350>
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53(4), 695–699. <https://doi.org/10.1111/j.1532-5415.2005.53221.x>
- Nielsen, S. E., Ahmed, I., & Cahill, L. (2014). Postlearning stress differentially affects memory for emotional gist and detail in naturally cycling women and women on hormonal contraceptives. *Behavioral Neuroscience*, 128(4), 482–493. <https://doi.org/10.1037/a0036687>
- Noachtar, I. A., Hidalgo-Lopez, E., & Pletzer, B. (2022). Duration of oral contraceptive use relates to cognitive performance and brain activation in current and past users. *Frontiers in Endocrinology*, 13. <https://doi.org/10.3389/fendo.2022.885617>
- Norman, A. L., Woodard, J. L., Calamari, J. E., Gross, E. Z., Pontarelli, N., Socha, J., DeJong, B., & Armstrong, K. (2020). The fear of Alzheimer’s disease: Mediating effects of anxiety on subjective memory complaints. *Aging & Mental Health*, 24(2), 308–314. <https://doi.org/10.1080/13607863.2018.1534081>
- Nwakanma, A., Ekanem, T., Eluwa, M., Elemuo, C., & Ekong, M. (2021). Ethinyl Estradiol/Progestin Oral Contraceptives Depress Spatial Learning and Dysregulate Hippocampal CA3 Microstructure: Implications for Behavioral-Cognitive Effects of Chronic Contraceptive Use? *Acta Medica Bulgarica*, 48(2), 53–61. <https://doi.org/10.2478/amb-2021-0024>

- Orrù, G., Gemignani, A., Cipriani, E., Miccoli, M., Ciacchini, R., Cancemi, C., Menicucci, D., Montiel, C. B., Piarulli, A., & Conversano, C. (2023). The hidden impact of Covid-19 on memory: Disclosing subjective complaints. *Clinical Neuropsychiatry*, 20(6), 495–504. <https://doi.org/10.36131/cnfioritieditore20230604>
- Ossewaarde, L., van Wingen, G. A., Rijpkema, M., Bäckström, T., Hermans, E. J., & Fernández, G. (2011). Menstrual cycle-related changes in amygdala morphology are associated with changes in stress sensitivity. *Human Brain Mapping*, 34(5), 1187–1193. <https://doi.org/10.1002/hbm.21502>
- Österlund, M. K., Gustafsson, J.-Å., Keller, E., & Hurd, Y. L. (2000). Estrogen Receptor β (ER β) Messenger Ribonucleic Acid (mRNA) Expression within the Human Forebrain: Distinct Distribution Pattern to ER α mRNA. *The Journal of Clinical Endocrinology & Metabolism*, 85(10), 3840–3846. <https://doi.org/10.1210/jcem.85.10.6913>
- Papp, K. V., Amariglio, R. E., Dekhtyar, M., Roy, K., Wigman, S., Bamfo, R., Sherman, J., Sperling, R. A., & Rentz, D. M. (2014). Development of a Psychometrically Equivalent Short Form of the Face–Name Associative Memory Exam for use Along the Early Alzheimer’s Disease Trajectory. *The Clinical Neuropsychologist*, 28(5), 771–785. <https://doi.org/10.1080/13854046.2014.911351>
- Parisi, J. M., Gross, A. L., Rebok, G. W., Saczynski, J. S., Crowe, M., Cook, S. E., Langbaum, J. B. S., Sartori, A., & Unverzagt, F. W. (2011). Modeling change in memory performance and memory perceptions: Findings from the ACTIVE study. *Psychology and Aging*, 26(3), 518–524. <https://doi.org/10.1037/a0022458>
- Pearman, A. (2009). Predictors of subjective memory in young adults. *Journal of Adult Development*, 16(2), 101–107. <https://doi.org/10.1007/s10804-009-9063-1>
- Pearman, A., & Storandt, M. (2004). Predictors of subjective memory in older adults. *The Journals of Gerontology: Series B*, 59(1), P4–P6. <https://doi.org/10.1093/geronb/59.1.P4>

- Peavy, G. M., Santiago, D. P., & Edland, S. D. (2013). Subjective memory complaints are associated with diurnal measures of salivary cortisol in cognitively intact older adults. *The American Journal of Geriatric Psychiatry*, 21(9), 925–928. <https://doi.org/10.1016/j.jagp.2013.01.022>
- Peragine, D., Simeon-Spezzaferro, C., Brown, A., Gervais, N. J., Hampson, E., & Einstein, G. (2020). Sex difference or hormonal difference in mental rotation? The influence of ovarian milieu. *Psychoneuroendocrinology*, 115, 104488. <https://doi.org/10.1016/j.psyneuen.2019.104488>
- Petersen, N., Beltz, A. M., Casto, K. V., Taylor, C. M., Jacobs, E. G., Sundström-Poromaa, I., & Pletzer, B. (2023). Towards a more comprehensive neuroscience of hormonal contraceptives. *Nature Neuroscience*, 26(4), 529–531. <https://doi.org/10.1038/s41593-023-01273-z>
- Petersen, N., & Cahill, L. (2015). Amygdala reactivity to negative stimuli is influenced by oral contraceptive use. *Social Cognitive and Affective Neuroscience*, 10(9), 1266–1272. <https://doi.org/10.1093/scan/nsv010>
- Petersen, N., Kearley, N. W., Ghahremani, D. G., Pochon, J.-B., Fry, M. E., Rapkin, A. J., & London, E. D. (2021). Effects of oral contraceptive pills on mood and magnetic resonance imaging measures of prefrontal cortical thickness. *Molecular Psychiatry*, 26(3), 917–926. <https://doi.org/10.1038/s41380-020-00990-2>
- Petersen, N., Kilpatrick, L. A., Goharзад, A., & Cahill, L. (2014). Oral contraceptive pill use and menstrual cycle phase are associated with altered resting state functional connectivity. *NeuroImage*, 90, 24–32. <https://doi.org/10.1016/j.neuroimage.2013.12.016>
- Phillips, S. M., & Sherwin, B. B. (1992). Variations in memory function and sex steroid hormones across the menstrual cycle. *Psychoneuroendocrinology*, 17(5), 497–506. [https://doi.org/10.1016/0306-4530\(92\)90008-u](https://doi.org/10.1016/0306-4530(92)90008-u)

- Plamberger, C. P., Van Wijk, H. E., Kerschbaum, H., Pletzer, B. A., Gruber, G., Oberascher, K., Dresler, M., Hahn, M. A., & Hoedlmoser, K. (2021). Impact of menstrual cycle phase and oral contraceptives on sleep and overnight memory consolidation. *Journal of Sleep Research*, 30(4), e13239. <https://doi.org/10.1111/jsr.13239>
- Pletzer, B. A., & Kerschbaum, H. H. (2014). 50 years of hormonal contraception—Time to find out, what it does to our brain. *Frontiers in Neuroscience*, 8. <https://www.frontiersin.org/article/10.3389/fnins.2014.00256>
- Pletzer, B., Comasco, E., Hidalgo-Lopez, E., Lacreuse, A., & Derntl, B. (2023a). Editorial: Effects of hormonal contraceptives on the brain. *Frontiers in Endocrinology*, 14. <https://doi.org/10.3389/fendo.2023.1129203>
- Pletzer, B., Crone, J. S., Kronbichler, M., & Kerschbaum, H. (2016). Menstrual Cycle and Hormonal Contraceptive-Dependent Changes in Intrinsic Connectivity of Resting-State Brain Networks Correspond to Behavioral Changes Due to Hormonal Status. *Brain Connectivity*, 6(7), 572–585. <https://doi.org/10.1089/brain.2015.0407>
- Pletzer, B., Harris, T., & Hidalgo-Lopez, E. (2019a). Previous contraceptive treatment relates to grey matter volumes in the hippocampus and basal ganglia. *Scientific Reports*, 9(1), 11003. <https://doi.org/10.1038/s41598-019-47446-4>
- Pletzer, B., Kronbichler, M., Aichhorn, M., Bergmann, J., Ladurner, G., & Kerschbaum, H. H. (2010). Menstrual cycle and hormonal contraceptive use modulate human brain structure. *Brain Research*, 1348, 55–62. <https://doi.org/10.1016/j.brainres.2010.06.019>
- Pletzer, B., Kronbichler, M., & Kerschbaum, H. (2015a). Differential effects of androgenic and anti-androgenic progestins on fusiform and frontal gray matter volume and face recognition performance. *Brain Research*, 1596, 108–115. <https://doi.org/10.1016/j.brainres.2014.11.025>

- Pletzer, B., Kronbichler, M., Nuerk, H.-C., & Kerschbaum, H. (2014). Hormonal contraceptives masculinize brain activation patterns in the absence of behavioral changes in two numerical tasks. *Brain Research*, 1543, 128–142. <https://doi.org/10.1016/j.brainres.2013.11.007>
- Pletzer, B., Lang, C., Derntl, B., & Griksiene, R. (2022). Weak associations between personality and contraceptive choice. *Frontiers in Neuroscience*, 16. <https://www.frontiersin.org/articles/10.3389/fnins.2022.898487>
- Pletzer, B., Petasis, O., Ortner, T., & Cahill, L. (2015b). Interactive effects of culture and sex hormones on the sex role self-concept. *Frontiers in Neuroscience*, 9. <https://doi.org/10.3389/fnins.2015.00240>
- Pletzer, B., Steinbeisser, J., van Laak, L., & Harris, T. (2019b). Beyond biological sex: Interactive effects of gender role and sex hormones on spatial abilities. *Frontiers in Neuroscience*, 13, 675. <https://doi.org/10.3389/fnins.2019.00675>
- Pletzer, B., Winkler-Crepaz, K., & Maria Hillerer, K. (2023b). Progesterone and contraceptive progestin actions on the brain: A systematic review of animal studies and comparison to human neuroimaging studies. *Frontiers in Neuroendocrinology*, 69, 101060. <https://doi.org/10.1016/j.yfrne.2023.101060>
- Pluchino, N., Luisi, M., Lenzi, E., Centofanti, M., Begliuomini, S., Freschi, L., Ninni, F., & Genazzani, A. R. (2006). Progesterone and progestins: Effects on brain, allopregnanolone and beta-endorphin. *The Journal of Steroid Biochemistry and Molecular Biology*, 102(1–5), 205–213. <https://doi.org/10.1016/j.jsbmb.2006.09.023>
- Podlesek, A., Komidar, L., & Kavcic, V. (2021). The relationship between perceived stress and subjective cognitive decline during the COVID-19 epidemic. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.647971>

- Porcu, P., Serra, M., & Concas, A. (2019). The brain as a target of hormonal contraceptives: Evidence from animal studies. *Frontiers in Neuroendocrinology*, 55, 100799.
<https://doi.org/10.1016/j.yfrne.2019.100799>
- Posit team. (2023). RStudio: Integrated Development Environment for R. Posit Software, PBC.
<http://posit.co/>
- Posit team (2025). RStudio: Integrated Development Environment for R. Posit Software, PBC, Boston, MA. <http://posit.co/>
- Preston, A. R., & Eichenbaum, H. (2013). Interplay of Hippocampus and Prefrontal Cortex in Memory. *Current Biology*, 23(17), R764–R773. <https://doi.org/10.1016/j.cub.2013.05.041>
- Pritschet, L., Santander, T., Taylor, C. M., Layher, E., Yu, S., Miller, M. B., Grafton, S. T., & Jacobs, E. G. (2020). Functional reorganization of brain networks across the human menstrual cycle. *NeuroImage*, 117091. <https://doi.org/10.1016/j.neuroimage.2020.117091>
- Protopopescu, X., Butler, T., Pan, H., Root, J., Altemus, M., Polanecsky, M., McEwen, B., Silbersweig, D., & Stern, E. (2008). Hippocampal structural changes across the menstrual cycle. *Hippocampus*, 18(10), 985–988. <https://doi.org/10.1002/hipo.20468>
- Putnick, D. L., & Bornstein, M. H. (2016). Measurement invariance conventions and reporting: The state of the art and future directions for psychological research. *Developmental Review*, 41, 71–90. <https://doi.org/10.1016/j.dr.2016.06.004>
- Rabin, L. A., Sikkes, S. A. M., Tommet, D., Jones, R. N., Crane, P. K., Elbulok-Charcape, M. M., Dubbelman, M. A., Kosciak, R., Amariglio, R. E., Buckley, R. F., Boada, M., Chételat, G., Dubois, B., Ellis, K. A., Gifford, K. A., Jefferson, A. L., Jessen, F., Johnson, S., Katz, M. J., ... Wolfgruber, S. (2023). Linking self-perceived cognitive functioning questionnaires using item

response theory: The subjective cognitive decline initiative. *Neuropsychology*, 37(4), 463–499.

<https://doi.org/10.1037/neu0000888>

Rabipour, S. (2018). Effects of expectations on cognitive enhancement interventions in young and older adults [Université d'Ottawa / University of Ottawa].

<http://ruor.uottawa.ca/handle/10393/38157>.

Rabipour, S., Morrison, C., Crompton, J., Petrucelli, M., de Oliveira Gonçalves Germano, M., Popescu, A., & Davidson, P. S. R. (2020). Few effects of a 5-week adaptive computerized cognitive training program in healthy older adults. *Journal of Cognitive Enhancement*, 4(3), 258–273. <https://doi.org/10.1007/s41465-019-00147-2>

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1(3), 385–401.

<https://doi.org/10.1177/014662167700100306>

Radnan, M. J., Nicholson, R., Brookman, R., & Harris, C. B. (2023). Memory compensation strategies in everyday life: Similarities and differences between younger and older adults.

Scientific Reports, 13(1), 8404. <https://doi.org/10.1038/s41598-023-34815-3>

Raimo, S., Trojano, L., Siciliano, M., Cuoco, S., D'Iorio, A., Santangelo, F., Abbamonte, L., Grossi, D., & Santangelo, G. (2016). Psychometric properties of the Italian version of the multifactorial memory questionnaire for adults and the elderly. *Neurological Sciences*, 37(5), 681–691.

<https://doi.org/10.1007/s10072-016-2562-5>

Rapkin, A. J., Korotkaya, Y., & Taylor, K. C. (2019). Contraception counseling for women with premenstrual dysphoric disorder (PMDD): Current perspectives. *Open Access Journal of Contraception*, 10, 27–39. <https://doi.org/10.2147/OAJC.S183193>

- Rebchuk, A. D., Deptuck, H. M., O'Neill, Z. R., Fawcett, D. S., Silverberg, N. D., & Field, T. S. (2019). Validation of a Novel Telehealth Administration Protocol for the NIH Toolbox-Cognition Battery. *Telemedicine and E-Health*, 25(3), 237–242.
<https://doi.org/10.1089/tmj.2018.0023>
- Rekers, H., Norpoth, T., & Michaels, M. A. (1996). Oral contraceptive use and venous thromboembolism: A consideration of the impact of bias and confounding factors on epidemiological studies. *The European Journal of Contraception & Reproductive Health Care*, 1(1), 21–30. <https://doi.org/10.3109/13625187.11661691.1996>
- Rentz, D. M., Slotkin, J., Kaat, A. J., Young, S. R., Dworak, E. M., Shono, Y., Adam, H., Nowinski, C. J., Pila, S., Novack, M. A., Hosseinian, Z., Amagai, S., Diaz, M. V., Almonte-Correa, A., Alperin, K., Camacho, M. R., Landavazo, B., Nosheny, R. L., Weiner, M. W., & Gershon, R. C. (2025). Validity and reliability of the Mobile Toolbox Faces and Names memory test. *Journal of Neuropsychology*, 19(2), 390–396. <https://doi.org/10.1111/jnp.12394>
- Rentz, D. M., Weiss, B. K., Jacobs, E. G., Cherkerzian, S., Klibanski, A., Remington, A., Aizley, H., & Goldstein, J. M. (2017). Sex differences in episodic memory in early midlife: Impact of reproductive aging. *Menopause (New York, N.Y.)*, 24(4), 400–408.
<https://doi.org/10.1097/GME.0000000000000771>
- Resnick, A., Perry, W., Parry, B., Mostofi, N., & Udell, C. (1998). Neuropsychological performance across the menstrual cycle in women with and without premenstrual dysphoric disorder. *Psychiatry Research*, 77(3), 147–158. [https://doi.org/10.1016/S0165-1781\(97\)00142-X](https://doi.org/10.1016/S0165-1781(97)00142-X)
- Reuben, R., Karkaby, L., McNamee, C., Phillips, N. A., & Einstein, G. (2021). Menopause and cognitive complaints: Are ovarian hormones linked with subjective cognitive decline? *Climacteric*, 0(0), 1–12. <https://doi.org/10.1080/13697137.2021.1892627>

- Reynolds, C. A. & Charlton, B. M. (2021). Sexual behaviour and contraceptive use among cisgender and gender minority students who were assigned female at birth. *Journal of Pediatric and Adolescent Gynecology*, 34(4), 477-483. <https://doi.org/10.1016/j.jpag.2021.03.009>
- Rivera, R., Yacobson, I., & Grimes, D. (1999). The mechanism of action of hormonal contraceptives and intrauterine contraceptive devices. *American Journal of Obstetrics and Gynecology*, 181(5), 1263–1269. [https://doi.org/10.1016/S0002-9378\(99\)70120-1](https://doi.org/10.1016/S0002-9378(99)70120-1)
- Rizzi, E., Vezzoli, M., Pegoraro, S., Facchin, A., Strina, V., & Daini, R. (2023). Teleneuropsychology: Normative data for the assessment of memory in online settings. *Neurological Sciences*, 44(2), 529–538. <https://doi.org/10.1007/s10072-022-06426-9>
- Robakis, T., Williams, K. E., Nutkiewicz, L., & Rasgon, N. L. (2019). Hormonal Contraceptives and Mood: Review of the Literature and Implications for Future Research. *Current Psychiatry Reports*, 21(7), 57. <https://doi.org/10.1007/s11920-019-1034-z>
- Roberts, J. S., McLaughlin, S. J., & Connell, C. M. (2014). Public beliefs and knowledge about risk and protective factors for Alzheimer’s disease. *Alzheimer’s & Dementia*, 10(5S), S381–S389. <https://doi.org/10.1016/j.jalz.2013.07.001>
- Roche, D. J. O., King, A. C., Cohoon, A. J., & Lovallo, W. R. (2013). Hormonal contraceptive use diminishes salivary cortisol response to psychosocial stress and naltrexone in healthy women. *Pharmacology, Biochemistry, and Behavior*, 109, 84–90. <https://doi.org/10.1016/j.pbb.2013.05.007>
- Roe, A. H., Kumar-Kaparbony, P., Nathan, M., & Dutton, C. (2020). Effects of Hormonal Contraception on Mood. *Current Obstetrics and Gynecology Reports*, 9(3), 112–119. <https://doi.org/10.1007/s13669-020-00295-9>

- Rosenberg, L., & Park, S. (2002). Verbal and spatial functions across the menstrual cycle in healthy young women. *Psychoneuroendocrinology*, 27(7), 835–841. [https://doi.org/10.1016/s0306-4530\(01\)00083-x](https://doi.org/10.1016/s0306-4530(01)00083-x)
- Rosenberg, M. J., & Waugh, M. S. (1998). Oral contraceptive discontinuation: A prospective evaluation of frequency and reasons. *American Journal of Obstetrics and Gynecology*, 179(3), 577–582. [https://doi.org/10.1016/S0002-9378\(98\)70047-X](https://doi.org/10.1016/S0002-9378(98)70047-X)
- Rossetti, M. F., Cambiasso, M. J., Holschbach, M. A., & Cabrera, R. (2016). Oestrogens and Progestagens: Synthesis and Action in the Brain. *Journal of Neuroendocrinology*, 28(7). <https://doi.org/10.1111/jne.12402>
- Ruehr, L., Hoffmann, K., May, E., Münch, M. L., Schlögl, H., & Sacher, J. (2025). Estrogens and human brain networks: A systematic review of structural and functional neuroimaging studies. *Frontiers in Neuroendocrinology*, 77, 101174. <https://doi.org/10.1016/j.yfrne.2024.101174>
- Ryan, A. D., & Campbell, K. L. (2024). Time spent imagining does not influence younger and older adults' episodic simulation of helping behavior. *Aging, Neuropsychology, and Cognition*, 1–18. <https://doi.org/10.1080/13825585.2024.2327677>
- Sahlberg, B.-L., Landgren, B.-M., & Axelson, M. (1987). Metabolic profiles of endogenous and ethynyl steroids in plasma and urine from women during administration of oral contraceptives. *Journal of Steroid Biochemistry*, 26(5), 609–617. [https://doi.org/10.1016/0022-4731\(87\)90014-8](https://doi.org/10.1016/0022-4731(87)90014-8)
- Salk, R. H., Hyde, J. S., & Abramson, L. Y. (2017). Gender differences in depression in representative national samples: Meta-analyses of diagnoses and symptoms. *Psychological Bulletin*, 143(8), 783–822. <https://doi.org/10.1037/bul0000102>
- Sajadian, M., Jalilvand, H., Mohammadzadeh, A., Pourdad, B., Sajadian, M., Gohari, N., & Tabatabaee, S. M. (2021). Auditory-verbal memory function of women during the menstruation

and ovulation periods. *Auditory and Vestibular Research*, 30(4), 294–299.

<https://doi.org/10.18502/avr.v30i4.7449>

Sanders, S. A., Graham, C. A., Bass, J. L., & Bancroft, J. (2001). A prospective study of the effects of oral contraceptives on sexuality and well-being and their relationship to discontinuation.

Contraception, 64(1), 51–58. [https://doi.org/10.1016/S0010-7824\(01\)00218-9](https://doi.org/10.1016/S0010-7824(01)00218-9)

Sänger, N., Stahlberg, S., Manthey, T., Mittmann, K., Mellinger, U., Lange, E., Kuhl, H., & Wiegratz, I. (2008). Effects of an oral contraceptive containing 30 mcg ethinyl estradiol and 2 mg dienogest on thyroid hormones and androgen parameters: Conventional vs. extended-cycle use.

Contraception, 77(6), 420–425. <https://doi.org/10.1016/j.contraception.2008.02.005>

Schaafsma, M., Homewood, J., & Taylor, A. (2010). Subjective cognitive complaints at menopause associated with declines in performance of verbal memory and attentional processes.

Climacteric, 13(1), 84–98. <https://doi.org/10.3109/13697130903009187>

Schaffir, J., Worly, B. L., & Gur, T. L. (2016). Combined hormonal contraception and its effects on mood: A critical review. *The European Journal of Contraception & Reproductive Health Care*, 21(5), 347–355. <https://doi.org/10.1080/13625187.2016.1217327>

Schindler, A. E. (2015). Pharmacology of Progestogens. In H. J. A. Carp (Ed.), *Progestogens in Obstetrics and Gynecology* (pp. 33–40). Springer International Publishing.

https://doi.org/10.1007/978-3-319-14385-9_2

Schroeder, S. R., & Marian, V. (2012). A bilingual advantage for episodic memory in older adults.

Journal of Cognitive Psychology, 24(5), 591–601.

<https://doi.org/10.1080/20445911.2012.669367>

Schultheiss, O. C., Köllner, M. G., Busch, H., & Hofer, J. (2021). Evidence for a robust, estradiol-associated sex difference in narrative-writing fluency. *Neuropsychology*, 35(3), 323–333.

<https://doi.org/10.1037/neu0000706>

Schulz, K. M., & Sisk, C. L. (2016). The organizing actions of adolescent gonadal steroid hormones on brain and behavioral development. *Neuroscience & Biobehavioral Reviews, The Adolescent Brain*, 70, 148–158. <https://doi.org/10.1016/j.neubiorev.2016.07.036>

Segal, S. K., Simon, R., McFarlin, S., Alkire, M., Desai, A., & Cahill, L. F. (2014). Glucocorticoids interact with noradrenergic activation at encoding to enhance long-term memory for emotional material in women. *Neuroscience*, 277, 267–272.

<https://doi.org/10.1016/j.neuroscience.2014.06.059>

Shahnazi, M., Farshbaf Khalili, A., Ranjbar Kochaksaraei, F., Asghari Jafarabadi, M., Gaza Banoi, K., Nahae, J., & Bayati Payan, S. (2014). A Comparison of Second and Third Generations Combined Oral Contraceptive Pills' Effect on Mood. *Iranian Red Crescent Medical Journal*, 16(8), e13628. <https://doi.org/10.5812/iremj.13628>

Shaikh, K. T., Tatham, E. L., Rich, J. B., & Troyer, A. K. (2021a). Examining the factor structure of the multifactorial memory questionnaire. *Memory (Hove, England)*, 29(2), 255–260.

<https://doi.org/10.1080/09658211.2021.1874995>

Shaikh, K. T., Tatham, E. L., Vandermorris, S., Paterson, T., Stokes, K., Freedman, M., Levine, B., Rich, J. B., & Troyer, A. K. (2021b). The impact of memory change on everyday life among older adults: Association with cognition and self-reported memory. *Journal of the International Neuropsychological Society*, 27(9), 896–904. <https://doi.org/10.1017/S1355617720001344>

- Sharma, R., Fang, Z., Smith, A., & Ismail, N. (2020a). Oral contraceptive use, especially during puberty, alters resting state functional connectivity. *Hormones and Behavior*, 126, 104849. <https://doi.org/10.1016/j.yhbeh.2020.104849>
- Sharma, R., Smith, S. A., Boukina, N., Dordari, A., Mistry, A., Taylor, B. C., Felix, N., Cameron, A., Fang, Z., Smith, A., & Ismail, N. (2020b). Use of the birth control pill affects stress reactivity and brain structure and function. *Hormones and Behavior*, 124, 104783. <https://doi.org/10.1016/j.yhbeh.2020.104783>
- Sherwin, B. B. (2005). Estrogen and memory in women: How can we reconcile the findings? *Hormones and Behavior*, 47(3), 371–375. <https://doi.org/10.1016/j.yhbeh.2004.12.002>
- Shields, G. S., Sazma, M. A., McCullough, A. M., & Yonelinas, A. P. (2017). The effects of acute stress on episodic memory: A meta-analysis and integrative review. *Psychological Bulletin*, 143(6), 636–675. <https://doi.org/10.1037/bul0000100>
- Shughrue, P. J., Lane, M. V., & Merchenthaler, I. (1997). Comparative distribution of estrogen receptor- α and - β mRNA in the rat central nervous system. *Journal of Comparative Neurology*, 388(4), 507–525. [https://doi.org/10.1002/\(SICI\)1096-9861\(19971201\)388:4<507::AID-CNE1>3.0.CO;2-6](https://doi.org/10.1002/(SICI)1096-9861(19971201)388:4<507::AID-CNE1>3.0.CO;2-6)
- Silber, M., Almkvist, O., Larsson, B., Stock, S., & Uvnäs-Moberg, K. (1987). The effect of oral contraceptive pills on levels of oxytocin in plasma and on cognitive functions. *Contraception*, 36(6), 641–650. [https://doi.org/10.1016/0010-7824\(87\)90037-0](https://doi.org/10.1016/0010-7824(87)90037-0)
- Silverman, I., Choi, J., & Peters, M. (2007). The Hunter-Gatherer Theory of Sex Differences in Spatial Abilities: Data from 40 Countries. *Archives of Sexual Behavior*, 36(2), 261–268. <https://doi.org/10.1007/s10508-006-9168-6>

Singer, J. J., MacGregor, A. J., Cherkas, L. F., & Spector, T. D. (2005). Where did I leave my keys?

A twin study of self-reported memory ratings using the multifactorial memory questionnaire.

Twin Research and Human Genetics, 8(2), 108–112. <https://doi.org/10.1375/twin.8.2.108>

Sitruk-Ware, R. (2005). Pharmacology of different progestogens: The special case of drospirenone.

Climacteric: The Journal of the International Menopause Society, 8 Suppl 3, 4–12.

<https://doi.org/10.1080/13697130500330382>

Sitruk-Ware, R., & Nath, A. (2010). The use of newer progestins for contraception. *Contraception*,

82(5), 410–417. <https://doi.org/10.1016/j.contraception.2010.04.004>

Skirrow, C., Meszaros, M., Meepegama, U., Lenain, R., Papp, K. V., Weston, J., & Fristed, E. (2022).

Validation of a Remote and Fully Automated Story Recall Task to Assess for Early Cognitive

Impairment in Older Adults: Longitudinal Case-Control Observational Study. *JMIR Aging*, 5(3),

e37090. <https://doi.org/10.2196/37090>

Skovlund, C. W., Mørch, L. S., Kessing, L. V., & Lidegaard, Ø. (2016). Association of Hormonal

Contraception With Depression. *JAMA Psychiatry*, 73(11), 1154–1162.

<https://doi.org/10.1001/jamapsychiatry.2016.2387>

Slavin, M. J., Brodaty, H., Kochan, N. A., Crawford, J. D., Trollor, J. N., Draper, B., & Sachdev, P. S.

(2010). Prevalence and predictors of “subjective cognitive complaints” in the Sydney memory

and ageing study. *The American Journal of Geriatric Psychiatry*, 18(8), 701–710.

<https://doi.org/10.1097/JGP.0b013e3181df49fb>

Smith, G., Della Sala, S., Logie, R. H., & Maylor, E. A. (2000). Prospective and retrospective

memory in normal ageing and dementia: A questionnaire study. *Memory*, 8(5), 311–321.

<https://doi.org/10.1080/09658210050117735>

- Smith, C. C., Vedder, L. C., & McMahon, L. L. (2009). Estradiol and the relationship between dendritic spines, NR2B containing NMDA receptors, and the magnitude of long-term potentiation at hippocampal CA3–CA1 synapses. *Psychoneuroendocrinology*, 34, S130-S142. <http://doi.org/10.1016/j.psyneuen.2009.06.003>
- Song, J. Y., Patton, C. D., Friedman, R., Mahajan, L. S., Nordlicht, R., Sayed, R., & Lipton, M. L. (2023). Hormonal contraceptives and the brain: A systematic review on 60 years of neuroimaging, EEG, and biochemical studies in humans and animals. *Frontiers in Neuroendocrinology*, 68, 101051. <https://doi.org/10.1016/j.yfrne.2022.101051>
- Spreen, O., & Benton, A. L. (1977). Neurosensory centre comprehensive examination for aphasia: Manual of instructions. University of Victoria.
- Stamenova, V., Jennings, J. M., Cook, S. P., Walker, L. A. S., Smith, A. M., & Davidson, P. S. R. (2014). Training recollection in healthy older adults: Clear improvements on the training task, but little evidence of transfer. *Frontiers in Human Neuroscience*, 8. <https://www.frontiersin.org/articles/10.3389/fnhum.2014.00898>
- Stanford, E. J., Ramsden, T. J., & Shulman, L. P. (2004). 47—Modern Contraception in Men and Women. In M. J. Legato (Ed.), *Principles of Gender-Specific Medicine* (pp. 507–517). Academic Press. <https://doi.org/10.1016/B978-012440905-7/50316-9>
- Statistics Canada (2015, October 21). *Oral contraceptive use among women aged 15 to 49: Results from the Canadian Health Measures Survey*. <https://www150.statcan.gc.ca/n1/pub/82-003-x/2015010/article/14222-eng.htm>
- Steinberg, S. I., Negash, S., Sammel, M. D., Bogner, H., Harel, B. T., Livney, M. G., McCoubrey, H., Wolk, D. A., Kling, M. A., & Arnold, S. E. (2013). Subjective memory complaints, cognitive

performance, and psychological factors in healthy older adults. *American Journal of Alzheimer's Disease & Other Dementias*®, 28(8), 776–783. <https://doi.org/10.1177/1533317513504817>

Steinke, A., Kopp, B., & Lange, F. (2021). The Wisconsin Card Sorting Test: Split-half reliability estimates for a self-administered computerized variant. *Brain Sciences*, 11(5), 529. <https://doi.org/10.3390/brainsci11050529>

Stevens, R., Ochi, T., Wojcik, J., Cecula, P., Rueda Carrasco, E., & Lazorwitz, A. (2026). Patterns of contraceptive side-effect variation: Assessing medical and lifestyle factors associated with side-effects among those using hormonal contraception in the United Kingdom. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 323, 115125. <https://doi.org/10.1016/j.ejogrb.2026.115125>

Sunderland, A., Harris, J. E., & Baddeley, A. D. (1983). Do laboratory tests predict everyday memory? A neuropsychological study. *Journal of Verbal Learning and Verbal Behavior*, 22(3), 341–357. [https://doi.org/10.1016/S0022-5371\(83\)90229-3](https://doi.org/10.1016/S0022-5371(83)90229-3)

Sundström Poromaa, I., & Gingnell, M. (2014). Menstrual cycle influence on cognitive function and emotion processing—from a reproductive perspective. *Frontiers in Neuroscience*, 8, 380. <https://doi.org/10.3389/fnins.2014.00380>

Sundström-Poromaa, I. (2018). Chapter Thirteen—The Menstrual Cycle Influences Emotion but Has Limited Effect on Cognitive Function. In G. Litwack (Ed.), *Vitamins and Hormones* (Vol. 107, pp. 349–376). Academic Press. <https://doi.org/10.1016/bs.vh.2018.01.016>

Talboom, J. S., Håberg, A., De Both, M. D., Naymik, M. A., Schrauwen, I., Lewis, C. R., Bertinelli, S. F., Hammersland, C., Fritz, M. A., Myers, A. J., Hay, M., Barnes, C. A., Glisky, E., Ryan, L., & Huentelman, M. J. (2019). Family history of Alzheimer's disease alters cognition and is modified by medical and genetic factors. *eLife*, 8, e46179. <https://doi.org/10.7554/eLife.46179>

- Taler, V., Davidson, P. S. R., Sheppard, C., & Gardiner, J. (2021). A discourse-theoretic approach to story recall in aging and mild cognitive impairment. *Aging, Neuropsychology, and Cognition*, 28(5), 762–780. <https://doi.org/10.1080/13825585.2020.1821865>
- Tang, Y., Janssen, W. G. M., Hao, J., Roberts, J. A., McKay, H., Lasley, B., Allen, P. B., Greengard, P., Rapp, P. R., Kordower, J. H., Hof, P. R., & Morrison, J. H. (2004). Estrogen Replacement Increases Spinophilin-immunoreactive Spine Number in the Prefrontal Cortex of Female Rhesus Monkeys. *Cerebral Cortex*, 14(2), 215–223. <https://doi.org/10.1093/cercor/bhg121>
- Taxier, L. R., Gross, K. S., & Frick, K. M. (2020). Oestradiol as a neuromodulator of learning and memory. *Nature Reviews Neuroscience*, 21(10), Article 10. <https://doi.org/10.1038/s41583-020-0362-7>
- Taylor, C. M., Pritschet, L., & Jacobs, E. G. (2021). The scientific body of knowledge – Whose body does it serve? A spotlight on oral contraceptives and women’s health factors in neuroimaging. *Frontiers in Neuroendocrinology*, 60, 100874. <https://doi.org/10.1016/j.yfrne.2020.100874>
- Taylor, C. M., Pritschet, L., Olsen, R. K., Layher, E., Santander, T., Grafton, S. T., & Jacobs, E. G. (2020). Progesterone shapes medial temporal lobe volume across the human menstrual cycle. *NeuroImage*, 220, 117125. <https://doi.org/10.1016/j.neuroimage.2020.117125>
- The jamovi project (2025). jamovi (Version 2.6) [Computer Software]. Retrieved from <https://www.jamovi.org>
- Thrasher, C. A., Otto, L., & Harburger, L. L. (2023). The Effects of Hormone Contraceptives and Menstruation on Object Memory and Spatial Ability in Young Women. *Psychological Reports*, 126(5), 2403–2417. <https://doi.org/10.1177/00332941221079608>

- Toffol, E., Heikinheimo, O., Koponen, P., Luoto, R., & Partonen, T. (2011). Hormonal contraception and mental health: Results of a population-based study. *Human Reproduction*, 26(11), 3085–3093. <https://doi.org/10.1093/humrep/der269>
- Toffol, E., Heikinheimo, O., Koponen, P., Luoto, R., & Partonen, T. (2012). Further evidence for lack of negative associations between hormonal contraception and mental health. *Contraception*, 86(5), 470–480. <https://doi.org/10.1016/j.contraception.2012.02.014>
- Toffoletto, S., Lanzenberger, R., Gingnell, M., Sundström-Poromaa, I., & Comasco, E. (2014). Emotional and cognitive functional imaging of estrogen and progesterone effects in the female human brain: a systematic review. *Psychoneuroendocrinology*, 50, 28–52. <https://doi.org/10.1016/j.psyneuen.2014.07.025>
- Tomita, T., Sugawara, N., Kaneda, A., Okubo, N., Iwane, K., Takahashi, I., Kaneko, S., & Yasui-Furukori, N. (2014). Sex-specific effects of subjective memory complaints with respect to cognitive impairment or depressive symptoms. *Psychiatry and Clinical Neurosciences*, 68(3), 176–181. <https://doi.org/10.1111/pcn.12102>
- Tronson, N. C., & Schuh, K. M. (2022). Hormonal contraceptives, stress, and the brain: The critical need for animal models. *Frontiers in Neuroendocrinology*, 67, 101035. <https://doi.org/10.1016/j.yfrne.2022.101035>
- Troyer, A. K., Leach, L., Vandermorris, S., & Rich, J. B. (2019). The measurement of participant-reported memory across diverse populations and settings: A systematic review and meta-analysis of the Multifactorial Memory Questionnaire. *Memory (Hove, England)*, 27(7), 931–942. <https://doi.org/10.1080/09658211.2019.1608255>

- Troyer, A. K., & Rich, J. B. (2002). Psychometric properties of a new metamemory questionnaire for older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 57(1), P19–P27. <https://doi.org/10.1093/geronb/57.1.P19>
- Tulving, E. (1972). Episodic and semantic memory. *Organization of memory*, 1(381-403), 1.
- Tulving, E. (2002). Chronesthesia: Conscious awareness of subjective time. In *Principles of frontal lobe function* (pp. 311–325). Oxford University Press.
<https://doi.org/10.1093/acprof:oso/9780195134971.003.0020>
- Tuscher, J. J., Luine, V., Frankfurt, M., & Frick, K. M. (2016). Estradiol-Mediated Spine Changes in the Dorsal Hippocampus and Medial Prefrontal Cortex of Ovariectomized Female Mice Depend on ERK and mTOR Activation in the Dorsal Hippocampus. *Journal of Neuroscience*, 36(5), 1483–1489. <https://doi.org/10.1523/JNEUROSCI.3135-15.2016>
- Uittenhove, K., Jeanneret, S., & Vergauwe, E. (2023). *From Lab-Testing to Web-Testing in Cognitive Research: Who You Test is More Important than how You Test* (1). 6(1), Article 1.
<https://doi.org/10.5334/joc.259>
- United Nations Department of Economic and Social Affairs, Population Division (2022). *World Family Planning 2022: Meeting the changing needs for family planning: Contraceptive use by age and method*. UN DESA/POP/2022/TR/NO. 4.
- Unkenstein, A. E., Bryant, C. A., Judd, F. K., Ong, B., & Kinsella, G. J. (2016). Understanding women’s experience of memory over the menopausal transition: Subjective and objective memory in pre-, peri-, and postmenopausal women. *Menopause*, 23(12), 1319–1329.
<https://doi.org/10.1097/GME.0000000000000705>

- Uttl, B., Graf, P., & Richter, L. K. (2002). Verbal Paired Associates tests limits on validity and reliability. *Archives of Clinical Neuropsychology*, 17(6), 567–581.
[https://doi.org/10.1016/S0887-6177\(01\)00135-4](https://doi.org/10.1016/S0887-6177(01)00135-4)
- Valentine, J. C., Pigott, T. D., & Rothstein, H. R. (2010). How Many Studies Do You Need?: A Primer on Statistical Power for Meta-Analysis. *Journal of Educational and Behavioral Statistics*, 35(2), 215–247. <https://doi.org/10.3102/1076998609346961>
- Van der Elst, W., Hoogenhout, E. M., Dixon, R. A., De Groot, R. H. M., & Jolles, J. (2011). The Dutch memory compensation questionnaire: Psychometric properties and regression-based norms. *Assessment*, 18(4), 517–529. <https://doi.org/10.1177/1073191110370116>
- van der Werf, S. P., & Vos, S. H. (2011). Memory worries and self-reported daily forgetfulness: A psychometric evaluation of the Dutch translation of the multifactorial memory questionnaire. *The Clinical Neuropsychologist*, 25(2), 244–268. <https://doi.org/10.1080/13854046.2010.543290>
- Van Patten, R., Mulhauser, K., Austin, T. A., Bellone, J. A., Cotton, E., Chan, L., Twamley, E. W., Sawyer, K., & LaFrance, W. C. (2025). The association between subjective and objective cognitive functioning from a transdiagnostic perspective: An umbrella review and meta-analysis. *Clinical Psychology Review*, 121, 102648. <https://doi.org/10.1016/j.cpr.2025.102648>
- Varandas, M., & Ribeiro, F. (2024). Teleneuropsychology: Reliability and Acceptance in Memory Assessment. *Telemedicine Reports*, 5(1), 421–428. <https://doi.org/10.1089/tmr.2024.0066>
- Vargha-Khadem, F., Gadian, D. G., Watkins, K. E., Connelly, A., Van Paesschen, W., & Mishkin, M. (1997). Differential Effects of Early Hippocampal Pathology on Episodic and Semantic Memory. *Science*, 277(5324), 376–380. <https://doi.org/10.1126/science.277.5324.376>
- Velichkovsky, B. B., Razvaliaeva, A. Y., Khlebnikova, A. A., Manukyan, P. A., & Kasatkin, V. N. (2023). Attention and memory after COVID-19 as measured by neuropsychological tests:

Systematic review and meta-analysis. *Acta Psychologica*, 233, 103838.

<https://doi.org/10.1016/j.actpsy.2023.103838>

Voyer, D., Postma, A., Brake, B., & Imperato-McGinley, J. (2007). Gender differences in object location memory: A meta-analysis. *Psychonomic Bulletin & Review*, 14(1), 23–38.

<https://doi.org/10.3758/BF03194024>

Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables. *Psychological Bulletin*, 117(2), 250–270.

<https://doi.org/10.1037/0033-2909.117.2.250>

Waldron-Perrine, B., & Axelrod, B. N. (2012). Determining an appropriate cutting score for indication of impairment on the Montreal Cognitive Assessment. *International Journal of Geriatric Psychiatry*, 27(11), 1189–1194. <https://doi.org/10.1002/gps.3768>

Wang, A. C. J., Hara, Y., Janssen, W. G. M., Rapp, P. R., & Morrison, J. H. (2010). Synaptic Estrogen Receptor- α Levels in Prefrontal Cortex in Female Rhesus Monkeys and Their Correlation with Cognitive Performance. *Journal of Neuroscience*, 30(38), 12770–12776.

<https://doi.org/10.1523/JNEUROSCI.3192-10.2010>

Warren, A. M., Gurvich, C., Worsley, R., & Kulkarni, J. (2014). A systematic review of the impact of oral contraceptives on cognition. *Contraception*, 90(2), 111–116.

<https://doi.org/10.1016/j.contraception.2014.03.015>

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070. <https://doi.org/10.1037/0022-3514.54.6.1063>

Watts, A., Donofry, S., Ripperger, H., Eklund, N. M., Wan, L., Kang, C., Grove, G., Oberlin, L. E., Gujral, S., Vidoni, E. D., Burns, J. M., McAuley, E., Hillman, C. H., Kramer, A. F., Kamboh, M.

- I., & Erickson, K. I. (2025). Lifetime estrogen exposure and domain-specific cognitive performance: Results from the IGNITE study. *Frontiers in Aging Neuroscience*, 17. <https://doi.org/10.3389/fnagi.2025.1524474>
- Weber, M., Mapstone, M., Staskiewicz, J., & Maki, P. M. (2012). Reconciling subjective memory complaints with objective memory performance in the menopausal transition. *Menopause (New York, N.Y.)*, 19(7), 735–741. <https://doi.org/10.1097/gme.0b013e318241fd22>
- Wechsler, D. (1997). Wechsler Memory Scale (WMS-III). The Psychological Corporation.
- Weigold, A., Weigold, I. K., & Russell, E. J. (2013). Examination of the equivalence of self-report survey-based paper-and-pencil and internet data collection methods. *Psychological Methods*, 18(1), 53–70. <https://doi.org/10.1037/a0031607>
- Weiss, E. M., Kemmler, G., Deisenhammer, E. A., Fleischhacker, W. W., & Delazer, M. (2003). Sex differences in cognitive functions. *Personality and Individual Differences*, 35(4), 863–875. [https://doi.org/10.1016/S0191-8869\(02\)00288-X](https://doi.org/10.1016/S0191-8869(02)00288-X)
- Werner, P., Goldberg, S., Mandel, S., & Korczyn, A. D. (2013). Gender differences in lay persons' beliefs and knowledge about Alzheimer's disease (AD): A national representative study of Israeli adults. *Archives of Gerontology and Geriatrics*, 56(2), 400–404. <https://doi.org/10.1016/j.archger.2012.11.001>
- West, J. T., Wagner, R. L., Steinkrauss, A., & Dennis, N. A. (2025). Investigating the Cognitive Correlates of Semantic and Perceptual False Memory in Older and Younger Adults: A Multi-Group Latent Variable Approach. *Journal of Memory and Language*, 142, 104625. <https://doi.org/10.1016/j.jml.2025.104625>
- Westhoff, C. L., Heartwell, S., Edwards, S., Zieman, M., Stuart, G., Cwiak, C., Davis, A., Robilotto, T., Cushman, L., & Kalmuss, D. (2007). Oral contraceptive discontinuation: Do side effects

matter? *American Journal of Obstetrics and Gynecology*, 196(4), 412.e1-412.e7.

<https://doi.org/10.1016/j.ajog.2006.12.015>

Wharton, W., Hirshman, E., Merritt, P., Doyle, L., Paris, S., & Gleason, C. (2008). Oral contraceptives and androgenicity: Influences on visuospatial task performance in younger individuals. *Experimental and Clinical Psychopharmacology*, 16(2), 156–164.

<https://doi.org/10.1037/1064-1297.16.2.156>

Whitfield, K. (2005). *An investigation of the influence of gender and menstrual cycle phase on metacognitive judgments of efficacy* [Thesis, Department of Psychology - Simon Fraser University]. <https://summit.sfu.ca/item/10129>

Wiegatz, I., & Kuhl, H. (2006). Metabolic and clinical effects of progestogens. *The European Journal of Contraception & Reproductive Health Care*, 11(3), 153–161.

<https://doi.org/10.1080/13625180600772741>

Woolley, C. S., & McEwen, B. S. (1993). Roles of estradiol and progesterone in regulation of hippocampal dendritic spine density during the estrous cycle in the rat. *Journal of Comparative Neurology*, 336(2), 293–306. <https://doi.org/10.1002/cne.903360210>

World Health Organization. (2019). *Adolescent health*. Retrieved from: https://www.who.int/health-topics/adolescent-health#tab=tab_1

Wu, B., Goins, R. T., Laditka, J. N., Ignatenko, V., & Goedereis, E. (2009). Gender differences in views about cognitive health and healthy lifestyle behaviors among rural older adults. *The Gerontologist*, 49(S1), S72–S78. <https://doi.org/10.1093/geront/gnp077>

Yan, R., Portengen, C., Yang, T. A., Reece, G., Dunnum, Z., Hidalgo-Lopez, E., & Beltz, A. M. (2025). Hormonal intrauterine device use is related to mental rotations but not verbal memory skills. *Hormones and Behavior*, 175, 105804. <https://doi.org/10.1016/j.yhbeh.2025.105804>

- Yang, H.-L., Chou, K.-R., Lee, S.-C., Lin, P.-H., & Chiang, H.-Y. (2023). Test–retest reliability and random measurement error of the multifactorial memory questionnaire in older adults with subjective memory complaints. *Gerontology and Geriatric Medicine*, 9, 23337214231171981. <https://doi.org/10.1177/23337214231171981>
- Yoo, J. E., Shin, D. W., Han, K., Kim, D., Won, H.-S., Lee, J., Kim, S. Y., Nam, G. E., & Park, H. S. (2020). Female reproductive factors and the risk of dementia: A nationwide cohort study. *European Journal of Neurology*, 27(8), 1448–1458. <https://doi.org/10.1111/ene.14315>
- Young-Bernier, M. (2015). Marqueurs neurophysiologiques de la cognition et du vieillissement: Études par stimulation magnétique transcrânienne [Thesis]. Université d’Ottawa / University of Ottawa. <https://doi.org/10.20381/ruor-6795>
- Zacur, H. A., Burkman, R. T., Kimball, A. W., Kwiterovich, P., & Bell, W. R. (1992). Existence of multiple peaks in plasma ethinyl estradiol and norethindrone after oral administration of a contraceptive pill. *The Journal of Clinical Endocrinology & Metabolism*, 75(5), 1268–1272. <https://doi.org/10.1210/jcem.75.5.1430087>
- Zager Kocjan, G., Lavtar, D., & Sočan, G. (2023). The effects of survey mode on self-reported psychological functioning: Measurement invariance and latent mean comparison across face-to-face and web modes. *Behavior Research Methods*, 55(3), 1226–1243. <https://doi.org/10.3758/s13428-022-01867-8>
- Zelinski, E. M., & Gilewski, M. J. (2004). A 10-item Rasch modeled memory self-efficacy scale. *Aging & Mental Health*, 8(4), 293–306. <https://doi.org/10.1080/13607860410001709665>
- Zettermark, S., Vicente, R. P., & Merlo, J. (2018). Hormonal contraception increases the risk of psychotropic drug use in adolescent girls but not in adults: A pharmacoepidemiological study on

800 000 Swedish women. *PLOS ONE*, 13(3), e0194773.

<https://doi.org/10.1371/journal.pone.0194773>

Zhang, J., Tang, C., Oberly, P. J., Minnigh, M. B., Achilles, S. L., & Poloyac, S. M. (2019). A sensitive and robust UPLC–MS/MS method for quantitation of estrogens and progestogens in human serum. *Contraception*, 99(4), 244–250.

<https://doi.org/10.1016/j.contraception.2018.12.010>

Zhang, J.-Q., Cai, W.-Q., Zhou, D.-S., & Su, B.-Y. (2002). Distribution and differences of estrogen receptor beta immunoreactivity in the brain of adult male and female rats. *Brain Research*, 935(1), 73–80. [https://doi.org/10.1016/S0006-8993\(02\)02460-5](https://doi.org/10.1016/S0006-8993(02)02460-5)

Zhou, C., Wu, Q., Wang, Z., Wang, Q., Liang, Y., & Liu, S. (2020). The Effect of Hormone Replacement Therapy on Cognitive Function in Female Patients With Alzheimer’s Disease: A Meta-Analysis. *American Journal of Alzheimer’s Disease & Other Dementias®*, 35, 1533317520938585. <https://doi.org/10.1177/1533317520938585>

Zimmerman, Y., Eijkemans, M. J. C., Coelingh Bennink, H. J. T., Blankenstein, M. A., & Fauser, B. C. J. M. (2014). The effect of combined oral contraception on testosterone levels in healthy women: A systematic review and meta-analysis. *Human Reproduction Update*, 20(1), 76–105. <https://doi.org/10.1093/humupd/dmt038>

Zsido, R. G., Williams, A. N., Barth, C., Serio, B., Kurth, L., Mildner, T., Trampel, R., Beyer, F., Witte, A. V., Villringer, A., & Sacher, J. (2023). Ultra-high-field 7T MRI reveals changes in human medial temporal lobe volume in female adults during menstrual cycle. *Nature Mental Health*, 1(10), Article 10. <https://doi.org/10.1038/s44220-023-00125-w>

Zuloaga, D. G., Yahn, S. L., Pang, Y., Quihuis, A. M., Oyola, M. G., Reyna, A., Thomas, P., Handa, R. J., & Mani, S. K. (2012). Distribution and Estrogen Regulation of Membrane Progesterone

Receptor- β in the Female Rat Brain. *Endocrinology*, 153(9), 4432–4443.

<https://doi.org/10.1210/en.2012-1469>

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Appendix A. Study 1 Supplemental Materials

A1. Study 1 supplemental analyses

Table A1. Independent t-test results for individual MMQ items.

MMQ- Satisfaction items	Young adults		Older adults		<i>t</i>	df	<i>p</i> (unadjusted)	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>				
1	2.67	0.99	2.45	1.09	2.30	a	395	0.022
2	3.14	0.98	3.09	0.94	0.59		504	0.559
3	3.35	0.73	3.23	0.82	1.68		504	0.094
4	3.47	0.88	2.69	1.13	8.59	a	443	<.001
5	2.81	1.11	2.83	0.95	-0.13	a	319	0.894
6	2.68	0.98	2.42	1.05	2.71		504	0.007
7	2.81	1.13	2.51	1.18	2.81		504	0.005
8	3.07	1.04	2.78	1.05	3.03		504	0.003
9	2.12	1.13	2.42	1.09	-2.91		504	0.004
10	2.84	1.16	2.16	1.19	6.21		504	<.001
11	3.08	1.03	1.69	1.03	4.07		504	<.001
12	2.76	0.99	2.41	1.12	3.56	a	404	<.001
13	1.99	1.13	2.36	1.05	-3.68		504	<.001
14	1.75	1.18	2.43	1.11	-6.43		504	<.001
15	3.19	0.99	2.79	1.04	4.26		504	<.001
16	1.58	1.14	1.80	1.11	-2.10		504	0.036
17	2.60	0.98	2.62	0.87	-0.17		504	0.862
18	2.94	1.04	2.38	1.15	5.60	a	397	<.001

MMQ- Ability items	Young adults		Older adults		<i>t</i>	df	<i>p</i> (unadjusted)	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>				
1	3.46	0.80	3.49	0.72	-0.56		504	0.578
2	2.38	1.13	2.43	0.97	-0.53	a	319	0.595
3	2.25	1.12	2.18	1.07	0.75		504	0.455
4	1.99	1.18	1.53	0.95	4.78		504	<.001
5	2.14	0.93	2.25	0.75	-1.31	a	303	0.19
6	3.34	0.74	3.43	0.71	-1.34		504	0.182
7	2.14	0.96	2.00	0.85	1.68	a	328	0.094
8	2.85	0.89	2.89	0.76	-0.50	a	319	0.621
9	2.11	1.12	2.04	0.86	0.67	a	293	0.506
10	2.80	0.98	2.23	0.87	6.63		504	<.001
11	3.17	1.07	3.32	0.74	-1.73	a	271	0.086
12	3.50	0.80	2.69	0.88	10.42	a	392	<.001
13	2.79	0.94	2.95	0.74	-1.88	a	300	0.061
14	2.39	1.04	2.50	0.77	-1.24	a	284	0.216

15	3.34	0.86	3.10	0.84	3.07		504	0.002	0.29
16	3.45	0.82	2.93	0.98	6.02		504	<.001	0.56
17	2.42	1.15	2.74	0.83	-3.23	^a	280	0.001	-0.31
18	2.38	1.01	2.37	0.80	0.12	^a	299	0.905	0.01
19	2.63	1.01	2.49	0.80	1.68	^a	299	0.093	0.16
20	2.74	0.95	2.52	0.82	2.69		504	0.007	0.25
MMQ- Strategies items	Older adults		Young adults		<i>t</i>		df	<i>p</i> (unadjusted)	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>					
1	2.46	1.37	1.46	1.31	-8.02		504	<.001	-0.75
2	1.85	1.10	1.38	0.90	4.90	^a	307	<.001	0.47
3	1.08	1.25	0.57	0.81	4.97	^a	259	<.001	0.49
4	1.94	1.26	1.39	1.11	5.14		504	<.001	0.48
5	3.04	1.22	3.75	0.51	-7.32	^a	211	<.001	-0.75
6	0.53	1.03	1.11	1.27	-5.62	^a	432	<.001	-0.51
7	1.62	1.42	1.44	1.36	1.44		504	0.151	0.13
8	2.57	1.23	2.00	1.21	5.04		504	<.001	0.47
9	3.00	1.08	2.73	1.11	2.65		504	0.008	0.25
10	2.81	1.28	3.38	0.91	-5.25	^a	277	<.001	-0.51
11	2.29	1.31	1.72	1.12	4.97	^a	319	<.001	0.47
12	2.70	1.19	3.00	0.88	-2.99	^a	286	0.003	-0.29
13	1.83	1.36	1.15	1.04	5.81	^a	290	<.001	0.56
14	1.47	1.32	0.77	0.93	6.26	^a	275	<.001	0.61
15	2.20	1.41	2.59	1.23	-3.15	^a	323	0.002	-0.30
16	1.28	1.39	0.73	1.02	4.64	^a	282	<.001	0.45
17	2.42	1.24	1.97	1.01	4.13	^a	305	<.001	0.40
18	2.26	1.43	2.38	1.26	-0.92	^a	326	0.359	-0.09
19	2.53	1.11	2.45	0.90	0.88	^a	307	0.377	0.08

Note. ^aWelch's correction was applied following significant Levene's test. Bolded items have significant adjusted *p*-values (i.e., with Holm-Bonferroni correction).

Table A2. Pearson correlations between individual MMQ items for each scale (in the combined sample of young and older adults)

		MMQ-Satisfaction																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	<i>r</i>	0.606	—															
	<i>p</i>	<.001	—															
3	<i>r</i>	0.42	0.404	—														
	<i>p</i>	<.001	<.001	—														
4	<i>r</i>	0.34	0.405	0.265	—													
	<i>p</i>	<.001	<.001	<.001	—													
5	<i>r</i>	0.495	0.555	0.346	0.293	—												
	<i>p</i>	<.001	<.001	<.001	<.001	—												
6	<i>r</i>	0.671	0.555	0.51	0.377	0.515	—											
	<i>p</i>	<.001	<.001	<.001	<.001	<.001	—											
7	<i>r</i>	0.599	0.585	0.358	0.495	0.532	0.579	—										
	<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	—										
8	<i>r</i>	0.454	0.441	0.33	0.459	0.414	0.45	0.589	—									
	<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—									
9	<i>r</i>	0.198	0.171	0.067	0.187	0.148	0.178	0.203	0.16	—								
	<i>p</i>	<.001	<.001	0.132	<.001	<.001	<.001	<.001	<.001	—								
10	<i>r</i>	0.59	0.557	0.316	0.566	0.473	0.544	0.665	0.58	0.151	—							
	<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—							
11	<i>r</i>	0.546	0.55	0.356	0.486	0.449	0.476	0.608	0.506	0.207	0.606	—						
	<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—						

5 <i>r</i>	0.342	0.47	0.339	0.316	—													
<i>p</i>	<.001	<.001	<.001	<.001	—													
6 <i>r</i>	0.385	0.361	0.28	0.267	0.423	—												
<i>p</i>	<.001	<.001	<.001	<.001	<.001	—												
7 <i>r</i>	0.217	0.328	0.254	0.317	0.384	0.27	—											
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	—											
8 <i>r</i>	0.329	0.36	0.304	0.238	0.425	0.478	0.412	—										
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—										
9 <i>r</i>	0.101	0.165	0.321	0.309	0.266	0.235	0.364	0.285	—									
<i>p</i>	0.023	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—									
10 <i>r</i>	0.172	0.155	0.349	0.405	0.24	0.247	0.358	0.299	0.487	—								
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—								
11 <i>r</i>	0.214	0.219	0.176	0.147	0.255	0.313	0.26	0.261	0.203	0.25	—							
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—							
12 <i>r</i>	0.213	0.161	0.255	0.38	0.225	0.304	0.314	0.238	0.279	0.409	0.197	—						
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—						
13 <i>r</i>	0.3	0.303	0.295	0.254	0.406	0.371	0.317	0.489	0.299	0.256	0.328	0.251	—					
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—					
14 <i>r</i>	0.143	0.216	0.277	0.257	0.333	0.277	0.47	0.329	0.493	0.39	0.261	0.251	0.37	—				
<i>p</i>	0.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—				
15 <i>r</i>	0.285	0.279	0.244	0.291	0.327	0.414	0.249	0.374	0.256	0.306	0.202	0.448	0.416	0.283	—			
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—			
16 <i>r</i>	0.188	0.157	0.383	0.34	0.169	0.287	0.256	0.252	0.221	0.381	0.177	0.487	0.273	0.285	0.499	—		
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—		
17 <i>r</i>	0.221	0.249	0.238	0.224	0.29	0.258	0.289	0.275	0.26	0.286	0.209	0.135	0.36	0.379	0.26	0.304	—	
<i>p</i>	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.002	<.001	<.001	<.001	<.001	—	
18 <i>r</i>	0.302	0.462	0.344	0.274	0.445	0.349	0.425	0.398	0.281	0.345	0.312	0.29	0.434	0.385	0.322	0.316	0.36	—

[illegible][illegible]

10	<i>r</i>	0.139	0.085	0.037	0.017	0.496	0.122	0.308	0.108	0.237	—								
	<i>p</i>	0.002	0.055	0.406	0.705	<.001	0.006	<.001	0.015	<.001	—								
11	<i>r</i>	0.201	0.154	0.285	0.352	0.001	0.136	0.309	0.395	0.337	0.12	—							
	<i>p</i>	<.001	<.001	<.001	<.001	0.985	0.002	<.001	<.001	<.001	0.007	—							
12	<i>r</i>	0.227	0.181	0.078	0.142	0.247	0.135	0.264	0.267	0.327	0.35	0.263	—						
	<i>p</i>	<.001	<.001	0.08	0.001	<.001	0.002	<.001	<.001	<.001	<.001	<.001	—						
13	<i>r</i>	0.168	0.223	0.404	0.317	-0.081	0.099	0.245	0.416	0.244	0.004	0.481	0.214	—					
	<i>p</i>	<.001	<.001	<.001	<.001	0.07	0.027	<.001	<.001	<.001	0.936	<.001	<.001	—					
14	<i>r</i>	0.168	0.12	0.482	0.454	-0.063	0.084	0.322	0.332	0.272	0.032	0.486	0.128	0.526	—				
	<i>p</i>	<.001	0.007	<.001	<.001	0.16	0.058	<.001	<.001	<.001	0.467	<.001	0.004	<.001	—				
15	<i>r</i>	0.146	0.055	0.095	0.18	0.315	0.19	0.249	0.171	0.267	0.394	0.214	0.333	0.124	0.229	—			
	<i>p</i>	<.001	0.217	0.033	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.005	<.001	—			
16	<i>r</i>	0.165	0.12	0.47	0.287	0.026	0.153	0.256	0.205	0.082	0.094	0.224	0.082	0.294	0.44	0.214	—		
	<i>p</i>	<.001	0.007	<.001	<.001	0.56	<.001	<.001	<.001	0.066	0.035	<.001	0.065	<.001	<.001	<.001	—		
17	<i>r</i>	0.138	0.203	0.282	0.346	0.006	0.134	0.214	0.358	0.253	0.053	0.371	0.253	0.415	0.325	0.233	0.225	—	
	<i>p</i>	0.002	<.001	<.001	<.001	0.892	0.003	<.001	<.001	<.001	0.235	<.001	<.001	<.001	<.001	<.001	<.001	—	
18	<i>r</i>	0.245	0.144	0.123	0.124	0.255	0.152	0.272	0.169	0.243	0.403	0.139	0.394	0.058	0.075	0.371	0.193	0.185	—
	<i>p</i>	<.001	0.001	0.006	0.005	<.001	<.001	<.001	<.001	<.001	<.001	0.002	<.001	0.191	0.092	<.001	<.001	<.001	—
19	<i>r</i>	0.15	0.259	0.186	0.288	0.086	0.158	0.198	0.289	0.281	0.146	0.273	0.3	0.236	0.193	0.242	0.104	0.378	0.249
	<i>p</i>	<.001	<.001	<.001	<.001	0.052	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.019	<.001	<.001

Table A3. Pearson correlations between MMQ scales and CES-D scores in young and older adults

Correlation Matrix – Young adults

		MMQ- Satisfaction	MMQ- Ability	MMQ- Strategies	MMQ- External Strategies	MMQ- Internal Strategies
CES-D score	Pearson's r	-0.395***	-0.300***	0.221**	0.198*	0.190*
	p-value	< .001	< .001	0.007	0.016	0.020
	95% CI	-0.250	-0.146	0.369	0.348	0.341
	Upper					
	95% CI	-0.523	-0.440	0.062	0.038	0.030
	Lower					

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Correlation Matrix – Older adults

		MMQ- Satisfaction	MMQ- Ability	MMQ- Strategies	MMQ- External Strategies	MMQ- Internal Strategies
CES-D score	Pearson's r	-0.344**	-0.220**	-0.024	-0.086	0.024
	p-value	< .001	0.001	0.737	0.222	0.731
	95% CI	-0.217	-0.086	0.114	0.052	0.160
	Upper					
	95% CI	-0.459	-0.347	-0.160	-0.220	-0.113
	Lower					

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

A2. Multifactorial Memory Questionnaire

Multifactorial Memory Questionnaire

How I Feel About My Memory

Name: _____ Date: _____

Below are statements about feelings that people may have about their memory. Read each statement and think about your feelings over the past *two weeks*. Then, check the box next to the response that best describes how much you agree or disagree.

-
1. I am generally pleased with my memory ability.
- 4** Strongly Agree **3** Agree **2** Undecided **1** Disagree **0** Strongly Disagree
-
2. There is something seriously wrong with my memory.
- 0** Strongly Agree **1** Agree **2** Undecided **3** Disagree **4** Strongly Disagree
-
3. If something is important, I will probably remember it.
- 4** Strongly Agree **3** Agree **2** Undecided **1** Disagree **0** Strongly Disagree
-
4. When I forget something, I fear that I may have a serious memory problem, like Alzheimer's disease.
- 0** Strongly Agree **1** Agree **2** Undecided **3** Disagree **4** Strongly Disagree
-
5. My memory is worse than most other people my age.
- 0** Strongly Agree **1** Agree **2** Undecided **3** Disagree **4** Strongly Disagree
-
6. I have confidence in my ability to remember things.
- 4** Strongly Agree **3** Agree **2** Undecided **1** Disagree **0** Strongly Disagree
-
7. I feel unhappy when I think about my memory ability.
- 0** Strongly Agree **1** Agree **2** Undecided **3** Disagree **4** Strongly Disagree
-
8. I worry that others will notice that my memory is not very good.
- 0** Strongly Agree **1** Agree **2** Undecided **3** Disagree **4** Strongly Disagree
-
9. When I have trouble remembering something, I'm not too hard on myself.
- 4** Strongly Agree **3** Agree **2** Undecided **1** Disagree **0** Strongly Disagree
-

Please turn page over to complete the questionnaire.

10. I am concerned about my memory.	0 Strongly Agree	1 Agree	2 Undecided	3 Disagree	4 Strongly Disagree
11. My memory is really going downhill lately.	0 Strongly Agree	1 Agree	2 Undecided	3 Disagree	4 Strongly Disagree
12. I am generally satisfied with my memory ability.	4 Strongly Agree	3 Agree	2 Undecided	1 Disagree	0 Strongly Disagree
13. I don't get upset when I have trouble remembering something.	4 Strongly Agree	3 Agree	2 Undecided	1 Disagree	0 Strongly Disagree
14. I worry that I will forget something important.	0 Strongly Agree	1 Agree	2 Undecided	3 Disagree	4 Strongly Disagree
15. I am embarrassed about my memory ability.	0 Strongly Agree	1 Agree	2 Undecided	3 Disagree	4 Strongly Disagree
16. I get annoyed or irritated with myself when I am forgetful.	0 Strongly Agree	1 Agree	2 Undecided	3 Disagree	4 Strongly Disagree
17. My memory is good for my age.	4 Strongly Agree	3 Agree	2 Undecided	1 Disagree	0 Strongly Disagree
18. I worry about my memory ability.	0 Strongly Agree	1 Agree	2 Undecided	3 Disagree	4 Strongly Disagree

**Multifactorial
Memory
Questionnaire**

Memory Mistakes

Name: _____ Date: _____

Below is a list of common memory mistakes that people make. Decide how often you have done each one in the *last two weeks*. Then, check the box next to the appropriate response.

1. Forget to pay a bill on time.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

2. Misplace something you use daily, like your keys or glasses.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

3. Have trouble remembering a telephone number you just looked up.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

4. Not recall the name of someone you just met.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

5. Leave something behind when you meant to bring it with you.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

6. Forget an appointment.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

7. Forget what you were just about to do; for example, walk into a room and forget what you went there to do.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

8. Forget to run an errand.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

9. In conversation, have difficulty coming up with a specific word that you want.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

Please turn page over to complete the questionnaire.

10. Have trouble remembering details from a newspaper or magazine article you read earlier that day.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

11. Forget to take medication.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

12. Not recall the name of someone you have known for some time.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

13. Forget to pass on a message.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

14. Forget what you were going to say in conversation.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

15. Forget a birthday or anniversary that you used to know well.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

16. Forget a telephone number you use frequently.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

17. Retell a story or joke to the same person because you forgot you already told him or her.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

18. Misplace something that you put away a few days ago.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

19. Forget to buy something you intended to buy.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

20. Forget details about a recent conversation.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

**Multifactorial
Memory
Questionnaire**
Use of Memory Strategies

Name: _____ Date: _____

People often use different tricks or strategies to help them remember things. Several strategies are listed below. Decide how often you used each one in the *last two weeks*. Then, check the box next to the appropriate response.

 1. Use a timer or alarm to remind you when to do something.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

2. Ask someone to help you remember something or to remind you to do something.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

3. Create a rhyme out of what you want to remember.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

4. In your mind, create an image of something you want to remember, like a name and face.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

5. Write things on a calendar, such as appointments or things you need to do.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

6. Go through the alphabet one letter at a time to see if it sparks a memory for a name or word.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

7. Organize information you want to remember; for example, organize your grocery list according to food groups.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

8. Say something out loud in order to remember it, such as a phone number you just looked up.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

9. Use a routine to remember important things, like checking that you have your wallet and keys when you leave home.

4 All the Time **3** Often **2** Sometimes **1** Rarely **0** Never

Please turn page over to complete the questionnaire.

10. Make a list, such as a grocery list or a list of things to do.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
11. Mentally elaborate on something you want to remember; for example, focus on a lot of the details.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
12. Put something in a prominent place to remind you to do something, like putting your umbrella by the front door so you will remember to take it with you.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
13. Repeat something to yourself at increasingly longer and longer intervals so you will remember it.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
14. Create a story to link together information you want to remember.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
15. Write down in a notebook things that you want to remember.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
16. Create an acronym out of the first letters in a list of things to remember, such as carrots, apples, and bread (cab).	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
17. Intentionally concentrate hard on something so that you will remember it.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
18. Write a note or reminder for yourself (other than on a calendar or in a notebook).	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never
19. Mentally retrace your steps in order to remember something, such as the location of a misplaced item.	4 All the Time	3 Often	2 Sometimes	1 Rarely	0 Never

Appendix B. Study 3 Supplemental Materials

B1. Supplemental study information and analyses

Story recall task transcription and scoring procedure

We followed the story recall transcription and scoring procedure developed by Hasanli et al. (Poster presentation at Cognitive Neuroscience Society Annual Meeting, 2026, Vancouver, BC). Traditionally, participants' responses to the Story Recall task used in the present study are manually scored by counting story units and classifying them as veridical, gist, or distortions/errors (Taler et al., 2021). This manual approach is time-intensive and can also prove subjective, especially when using multiple scorers. To address these limitations, here we employed an automated scoring method to evaluate story recall task performance.

Participants' verbal responses were first audio-recorded and transcribed into text using Whisper, an open-source speech-to-text system developed by OpenAI. All transcriptions were then checked for accuracy by the researcher. Prior to transcription, participant recordings were anonymized, and all processing was conducted locally to ensure data confidentiality.

Next, a large language model (LLM)-based approach was used to analyze the story recall transcripts. A standardized prompt incorporating the original story scoring rules (Taler et al., 2021) was applied, and individual participant transcripts were converted into batch job files for processing via the Vertex AI platform on Google Cloud. All LLM-based analyses were conducted using Gemini 2.5 flash, as newer batch-compatible versions were not yet publicly available.

To evaluate the reliability of this computational approach, a subset of story recall transcripts from the present dataset was scored twice (i.e., $n = 124$ Version 1 transcripts, $n = 117$ Version 2 transcripts), first using the traditional human-based scoring method and again using

the LLM-based automated scoring method. We assessed the level of agreement between automated and human-based scores with intraclass correlation coefficients (ICC) using the *psych* package in R Studio (Posit Team, 2025). Two-way mixed-effects, single-rater ICCs suggested excellent reliability of the automated scores for both Version 1 (ICC = 0.96; 95% CI: 0.94-0.97) and Version 2 of the task (ICC = 0.96; 95% CI: 0.88-0.94).

Finally, we also evaluated the test-retest reliability of the automated scoring method. Story transcripts from Part 1 were scored a second time (i.e., two months after our initial analysis) and the level of agreement between both sets of LLM-generated scores was assessed using the same method described above. Our results suggested excellent test-retest reliability of the automated scoring method for both Version 1 (ICC = 0.95; 95% CI: 0.94-0.96) and Version 2 of the task (ICC = 0.92; 95% CI: 0.90-0.93).

Executive control battery and analyses

Baseline executive control was assessed using three tasks known to be sensitive to PFC function (MacPherson et al., 2015), including Mental Control and Backward Digit Span from WMS-III (Wechsler, 1997), and verbal letter fluency (Spreen & Benton, 1977). All executive control tasks were administered remotely in their computerized versions. A composite score was created following the same method as for episodic memory.

In Part 1, ANCOVA was used to compare groups on the executive control composite, controlling for first language spoken by participants (coded as 1 = English, 0 = other). This analysis revealed no group differences on executive control, $F(1, 117) = .09, p = .762, \eta^2 < .001$. Similarly, in Part 2, executive control composites were created using the same method and factor weights as in Part 1. A one-way ANOVA of Time 1 scores revealed no significant group differences on executive control composites, $F(2, 111) = 0.03, p = .974, \eta^2 < .01$.

Additionally, because previous work has found inconsistent associations between verbal fluency and duration of OC use (e.g., Davignon et al., 2024; Hampson, 2025; Noachtar et al., 2022), we also examined this in the sample of OC users. Pearson correlations revealed a small positive correlation between verbal fluency scores and OC use duration that only approached significance, $r = .24, p = .079$.

Part 1 secondary and exploratory analyses

Table B1. Group comparisons on neuropsychological tasks and composites (Part 1)

	cOC (n = 60)		NC (n = 75)		<i>F</i> (df)	<i>p</i>	η^2
	M	SD	M	SD			
Memory composite*	0.20	1.09	-0.18	1.03	4.86 (1, 122)	0.029	0.04
FNPA Delayed	7.13	1.88	6.65	1.96	2.53 (1, 132)	0.114	0.02
VPA Delayed	6.88	3.76	5.84	2.96	3.45 (1, 132)	0.066	0.03
Story Recall Delayed	20.52	5.16	18.84	6.35	2.42 (1, 124)	0.122	0.02
4MT	12.20	2.90	11.24	3.20	3.05 (1, 132)	0.083	0.02
Executive control composite	0.05	1.04	-0.10	1.30	0.09 (1, 117)	0.762	<0.01
Mental Control	27.41	5.12	24.87	6.19	2.28 (1, 119)	0.134	0.02
Verbal Fluency	40.63	9.07	42.66	12.35	1.66 (1, 121)	0.200	0.01
Backward Digit Span	6.81	2.29	6.55	2.58	0.52 (1, 124)	0.476	<0.01

Note. First language included as covariate in all analyses. 4MT = Four Mountains Task; FNPA = Face-Name Paired Associates; VPA = Verbal Paired Associates. * $p < .05$.

Table B2. Pearson correlations between OC use duration and neuropsychological measures (Part 1)

	OC use duration	
	<i>r</i>	<i>p</i>
Memory composite	-0.01	0.974
FNPA Delayed	-0.02	0.909
VPA Delayed	-0.07	0.587
Story Recall Delayed	0.03	0.803
4MT	-0.08	0.541
Executive control composite	0.04	0.792
Mental Control	0.04	0.804
Verbal Fluency	0.16	0.235
Backward Digit Span	-0.08	0.541

Note. 4MT = Four Mountains Task; FNPA = Face-Name Paired Associates, VPA = Verbal Paired Associates.

Table B3. Pearson correlations between MMQ scales and CESD-10 (Part 1)

	CESD-10		
	All	cOC	NC
MMQ-Contentment	-0.46***	-0.33*	-0.52***
MMQ-Ability	-0.37***	-0.33*	-0.39***
MMQ-Strategies	0.30***	0.28*	0.30*
Internal Strategies	0.27**	0.19	0.31*
External Strategies	0.33***	0.34*	0.33**

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Comparisons of neuropsychological measures across progestin class (Part 1)

Effects of progestin class (i.e., generation) were examined using one-way ANOVAs on the episodic memory and executive control batteries. None of these analyses yielded significant results (see Table B4).

Table B4. Comparisons of neuropsychological measures across progestin class (Part 1)

	Gen. 1		Gen. 2		Gen. 3		Gen. 4		<i>F</i> (df)	<i>p</i>
	M	SD	M	SD	M	SD	M	SD		
Memory composite	-0.63	1.25	0.36	0.96	0.47	1.19	0.13	1.25	1.62 (3, 55)	0.194
FNPA Delayed	5.67	2.34	7.12	1.88	8.09	1.22	6.78	1.79	2.43 (3, 55)	0.075
VPA Delayed	5.83	5.04	7.12	3.62	6.64	3.26	7.44	4.36	0.27 (3, 55)	0.849
Story Recall Delayed	16.92	5.42	21.53	4.60	21.33	7.19	19.67	5.97	1.38 (3, 51)	0.258
4MT	11.33	2.34	12.15	3.07	12.36	2.80	13.22	2.64	0.55 (3, 55)	0.648
Executive control composite	0.43	1.27	0.15	0.94	-0.08	1.21	-0.43	0.66	1.16 (3, 55)	0.333
Mental Control	26.67	5.92	27.50	5.05	28.10	5.51	26.86	5.61	0.12 (3, 51)	0.945
Verbal Fluency	41.50	5.17	42.70	11.17	39.30	10.97	35.86	7.43	0.95 (3, 51)	0.422
Backward Digit Span	8.33	3.01	6.94	2.12	6.50	2.68	5.75	1.58	0.59 (3, 53)	0.203

Note. 4MT = Four Mountains Task; FNPA = Face-Name Paired Associates; VPA = Verbal Paired Associates.

Group comparisons on memory retention (Part 1)

Memory retention (between immediate and delayed recall conditions) was calculated for each individual memory task. ANCOVAs with immediate recall as covariate were conducted on delayed recall scores of VPA, FNPA, and Story recall, separately. None of these analyses emerged as significant (see Table B5).

Table B5. Group comparisons on memory retention (Part 1)

	<i>F</i> (df)	<i>p</i>	η^2
FNPA	1.15 (1, 132)	0.147	0.01
VPA	1.30 (1, 132)	0.452	< .01
Story Recall	1.04 (1, 122)	0.310	< .01

Note. FNPA = Face-Name Paired Associates; VPA = Verbal Paired Associates.

B2. Study recruitment and participant contact materials

Study recruitment poster (for new OC users)



Seeking participants for research on memory and the birth control pill

Are you considering starting the birth control pill?

The Neuropsychology Laboratory at the University of Ottawa is recruiting female participants to take part in research on memory function before and after starting the pill.

Are you eligible?

Eligible participants are:

- a) female, b) between 18 and 30 years old
- c) planning on starting a new birth control pill in the near future
- and d) have not taken any kind of hormonal contraceptive in the last 6 months

What will you be asked to do?

This is an **online study** that will involve completing:

- 7 cognitive tasks assessing your memory and executive functions
- 4 questionnaires assessing your mood, personality, and self-reported memory

This study will last approximately 1 hour and 25 minutes.

You will also be invited to take part in a follow-up study 3 months later.

Participants will receive up to \$45 in gift cards of their choice.

Want to participate?

Email us: OCstudy2020@gmail.com

Call us: (613) 562-5800, ext. 8757

Or scan the QR code to get in touch now



Principal Investigator: Adelaide Jensen, Ph.D. Candidate (Supervised by Dr. Patrick Davidson); School of Psychology, University of Ottawa

Study recruitment poster (for current OC users)



Seeking participants for research on memory and the birth control pill



Are you currently taking the birth control pill?

The Neuropsychology Laboratory at the University of Ottawa is recruiting female participants to take part in research on memory function in relation to birth control pill use.

Are you eligible?

Eligible participants are:

a) female, b) between 18 and 30 years old and c) have been taking a combined (i.e., containing estrogen and progestin) birth control pill for at least 6 months

What will you be asked to do?

This is an **online study** that will involve completing:

- 7 cognitive tasks assessing your memory and executive functions
- 4 questionnaires assessing your mood, personality, and self-reported memory

This study will last approximately 1 hour and 25 minutes.

You will also be invited to take part in a follow-up study 3 months later.

Participants will receive up to \$45 in gift cards of their choice.

Want to participate?

Email us: OCstudy2020@gmail.com

Call us: (613) 562-5800, ext. 8757

Or scan the QR code to get in touch now



Principal Investigator: Adelaide Jensen, Ph.D. Candidate (Supervised by Dr. Patrick Davidson); School of Psychology, University of Ottawa

ISPR study description (for new OC users)Time 1 session

Study Name	Let's test your memory!
Duration	85 minutes
Points	1.5 points
Abstract	We are studying the effects of the menstrual cycle and birth control pill use on memory and complex mental functions.
Description	**Because we are studying how the menstrual cycle affects memory abilities, we ask that you please complete this study during the first week of your menstrual cycle (i.e., during menses/your period).** During this study, you will be asked to complete 7 cognitive tasks assessing your memory and complex mental functions. You will also be asked to complete some questionnaires asking about your menstrual cycle or oral contraceptive use, health, mood, personality, and self-reported memory ability. Some of these tasks will require you to speak into your microphone and your responses will be recorded. This is an online study, so you can complete it anywhere you can access a computer with stable Internet access. If you are interested in participating, please sign up for one of the available time slots. Once you select a time slot, you will be sent a link by email to complete the study independently. The session should take approximately 1 hour and 25 minutes to complete and you will receive 1.5 ISPR credits for your time. *This online study must be completed IN ONE SITTING on a laptop or desktop using either CHROME or FIREFOX. This study is not compatible with a smartphone or desktop or with other web browsers.* **Participants will also be invited by email to participate in a follow-up study 3 months later.**

Time 2 session

Study Name	Let's test your memory again!
Duration	75 minutes
Points	1.5 points
Abstract	We are studying the effects of the menstrual cycle and birth control pill use on memory and complex mental functions.
Description	This is a follow-up to the study "Let's test your memory!". You may only participate if you have taken part in the first study last semester (Fall 2023). *Because we are studying how the birth control pill affects memory abilities, we ask that you please complete this study during the inactive or pill-free

	week of your cycle (and NOT during one of the active pill weeks, i.e., when you are taking pills containing active hormones).* During this study, you will be asked to complete 4 cognitive tasks assessing your memory and complex mental functions. You will also be asked to complete some questionnaires asking about your menstrual cycle or oral contraceptive use, health, mood, personality, and self-reported memory ability. Some of these tasks will require you to speak into your microphone and your responses will be recorded. This is an online study, so you can complete it anywhere you can access a computer with stable Internet access. If you are interested in participating, please sign up for one of the available time slots. Once you select a time slot, you will be sent a link by email to complete the study independently. The session should take approximately 1 hour and 15 minutes to complete and you will receive 1.5 ISPR credits for your time. **This online study must be completed IN ONE SITTING on a laptop or desktop using either CHROME or FIREFOX. This study is not compatible with a smartphone or desktop or with other web browsers.**
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ISPR study description (for current OC users)

Time 1 session

Study Name	Let's test your memory!
Duration	85 minutes
Points	1.5 points
Abstract	We are studying the effects of the menstrual cycle and birth control pill use on memory and complex mental functions.
Description	**Because we are studying how the birth control pill affects memory abilities, we ask that you please complete this study during the inactive or pill-free week of your cycle (and NOT during one of the active pill weeks, i.e., when you are taking pills containing active hormones).** During this study, you will be asked to complete 7 cognitive tasks assessing your memory and complex mental functions. You will also be asked to complete some questionnaires asking about your menstrual cycle or oral contraceptive use, health, mood, personality, and self-reported memory ability. Some of these tasks will require you to speak into your microphone and your responses will be recorded. This is an online study, so you can complete it anywhere you can access a computer with stable Internet access. If you are interested in participating, please sign up for one of the available time slots. Once you select a time slot, you will be sent a link by email to complete the study independently.

	The session should take approximately 1 hour and 25 minutes to complete and you will receive 1.5 ISPR credits for your time. *This online study must be completed IN ONE SITTING on a laptop or desktop using either CHROME or FIREFOX. This study is not compatible with a smartphone or desktop or with other web browsers.* **Participants will also be invited by email to participate in a follow-up study 3 months later.**
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Time 2 session

Study Name	Let's test your memory again!
Duration	75 minutes
Points	1.5 points
Abstract	We are studying the effects of the menstrual cycle and birth control pill use on memory and complex mental functions.
Description	This is a follow-up to the study "Let's test your memory!". You may only participate if you have taken part in the first study last semester (Fall 2023). *Because we are studying how the birth control pill affects memory abilities, we ask that you please complete this study during the inactive or pill-free week of your cycle (and NOT during one of the active pill weeks, i.e., when you are taking pills containing active hormones).* During this study, you will be asked to complete 4 cognitive tasks assessing your memory and complex mental functions. You will also be asked to complete some questionnaires asking about your menstrual cycle or oral contraceptive use, health, mood, personality, and self-reported memory ability. Some of these tasks will require you to speak into your microphone and your responses will be recorded. This is an online study, so you can complete it anywhere you can access a computer with stable Internet access. If you are interested in participating, please sign up for one of the available time slots. Once you select a time slot, you will be sent a link by email to complete the study independently. The session should take approximately 1 hour and 15 minutes to complete and you will receive 1.5 ISPR credits for your time. **This online study must be completed IN ONE SITTING on a laptop or desktop using either CHROME or FIREFOX. This study is not compatible with a smartphone or desktop or with other web browsers.**

ISPR study description (for NC participants)

Time 1 session

Study Name	Let's test your memory!
Duration	85 minutes
Points	1.5 points
Abstract	We are studying the effects of the menstrual cycle and birth control pill use on memory and complex mental functions.
Description	**Because we are studying how the menstrual cycle affects memory abilities, we ask that you please complete this study during the first week of your menstrual cycle (i.e., during menses/your period).** During this study, you will be asked to complete 7 cognitive tasks assessing your memory and complex mental functions. You will also be asked to complete some questionnaires asking about your menstrual cycle or oral contraceptive use, health, mood, personality, and self-reported memory ability. Some of these tasks will require you to speak into your microphone and your responses will be recorded. This is an online study, so you can complete it anywhere you can access a computer with stable Internet access. If you are interested in participating, please sign up for one of the available time slots. Once you select a time slot, you will be sent a link by email to complete the study independently. The session should take approximately 1 hour and 25 minutes to complete and you will receive 1.5 ISPR credits for your time. *This online study must be completed IN ONE SITTING on a laptop or desktop using either CHROME or FIREFOX. This study is not compatible with a smartphone or desktop or with other web browsers.* **Participants will also be invited by email to participate in a follow-up study 3 months later.**

Time 2 session

Study Name	Let's test your memory again!
Duration	75 minutes
Points	1.5 points
Abstract	We are studying the effects of the menstrual cycle and birth control pill use on memory and complex mental functions.
Description	This is a follow-up to the study "Let's test your memory!". You may only participate if you have taken part in the first study last semester (Fall 2023). *Because we are studying how the menstrual cycle affects memory abilities, we ask that you please complete this study during the first week of your menstrual cycle (i.e., during menses/your period).* During this study, you will be asked to complete 4 cognitive tasks assessing your memory and complex mental functions. You will also be asked to

	complete some questionnaires asking about your menstrual cycle or oral contraceptive use, health, mood, personality, and self-reported memory ability. Some of these tasks will require you to speak into your microphone and your responses will be recorded. This is an online study, so you can complete it anywhere you can access a computer with stable Internet access. If you are interested in participating, please sign up for one of the available time slots. Once you select a time slot, you will be sent a link by email to complete the study independently. The session should take approximately 1 hour and 15 minutes to complete and you will receive 1.5 ISPR credits for your time. **This online study must be completed IN ONE SITTING on a laptop or desktop using either CHROME or FIREFOX. This study is not compatible with a smartphone or desktop or with other web browsers.**
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T1 initial contact and screening email (for new OC users)

EMAIL #1 TEMPLATE

Hello,

Thank you for expressing interest in our study on birth control! Based on the responses you provided in the screening questionnaire we have determined that you might be eligible to participate in the study.

Before we can schedule your online testing session, we need to conduct a brief phone interview to confirm your eligibility. The call will take between **5-10 minutes** and will go over some important inclusion criteria and other study details.

To schedule your screening phone call, **please select a time window from our calendar** using the link below:

[link]

I will then call you during the time window that you selected. If you do not see any times that work for you, please let me know.

Thank you! Please don't hesitate to reach out if you have any questions or wish to reschedule.

PHONE INTERVIEW SCRIPT

Hi, this is Adelaide calling from the neuropsychology lab at the University of Ottawa. Am I speaking to ____?

I just wanted to call you to go over some important information about the study and confirm whether you are eligible to participate. This should only take about 5 minutes of your time.

First, I'm going to ask you a few screening questions.

1. In the screening questionnaire, you said you're planning on starting a new birth control prescription soon. Is that still the case?
2. Can you please confirm the brand name of the birth control you will be starting?
3. Have you already seen your doctor about starting this birth control, or do you have an appointment scheduled?
4. When exactly are you planning on starting your new birth control pill?
5. And can you please confirm that you have NOT taken any kind of hormonal birth control in the last 6 months?

Great, so you are eligible to participate. Thanks for answering these questions again! Now I'll just go over some important information about the study.

So in this study we are interested in finding out how using the birth control pill might affect people's memory and other cognitive functions. There are two testing sessions: the first session will take place before you begin taking your new birth control pill prescription, and the second session will take place after you will have been using your birth control pill for 3 months. So, once you complete the first testing session, we will contact you approximately 2-3 months later to book your second testing session.

The first testing session will last about 1 hour and 25 minutes and you'll be asked to complete some online memory tasks and answer some questionnaires. At the end of the first session, you will receive a \$15 gift card of your choice for your participation. Similarly, the second testing session will last about 1 hour and you will be asked to complete the same tasks and questionnaires as before, and you'll receive a \$30 gift card of your choice.

So far so good?

To prepare for your testing session, you'll need to have a working desktop or laptop with stable internet access. This study is NOT compatible with smartphones or tablets, so please only use your computer. Also, please ensure that you complete the study in one sitting and in a quiet space where you won't be distracted. For some of the tasks, your responses will be recorded, so you will need to have a functioning microphone. Is that ok?

After our phone call, I'm going to send you an email with the study's informed consent form and a link to our calendar. When you click on this link, you'll have to select a date and time to complete your first testing session. There are two important things to know about scheduling your session: First, like I mentioned before, please make sure you book a time slot BEFORE you begin taking your new birth control prescription. And second, we are asking our participants to book their session for when they are menstruating/on their period. This is because we want to make sure that everyone is in approximately the same phase of their menstrual cycle. (Do you know when your next period is going to be?)

Afterward, you will be sent the study link at the scheduled date and time, along with a couple email reminders about your upcoming testing session.

Do you have any questions?

EMAIL #2 TEMPLATE

Thank you for taking the time to complete the phone interview today! Please find attached the informed consent form with important information about the study (note that this is for your personal records and you do not need to sign it).

Please click [here](#) to schedule a time to complete the study. As a reminder, please make sure to select a time during your next menstrual phase/period BEFORE you begin taking your new birth control prescription. You will then be sent the study link at the scheduled date and time, as well as several reminders about the study.

The day of your online testing session, please follow the steps below:

1. Complete the study in ONE SITTING
2. Complete the study on a DESKTOP or LAPTOP with stable internet access (note that this study is only compatible with Google Chrome or Firefox)
3. Ensure that you are in a quiet space where you will not be distracted
4. Some of the tasks will require you to speak into your microphone and your responses will be recorded, so please ensure that you have a functioning microphone

Thank you! Please do not hesitate to email me if you have any questions or concerns.

T1 initial contact and screening email (for current OC users)

EMAIL #1 TEMPLATE

Hello,

Thank you for expressing interest in our study on birth control! Based on the responses you provided in the screening questionnaire we have determined that you might be eligible to participate in the study.

Before we can schedule your online testing session, we need to conduct a brief phone interview to confirm your eligibility. The call will take about **5-10 minutes** and will go over some important inclusion criteria and other study details.

To schedule your screening phone call, **please select a time window from our calendar** using the link below:

[link]

I will then call you during the time window that you selected. If you do not see any times that work for you, please let me know.

Thank you! Please don't hesitate to reach out if you have any questions or wish to reschedule.

PHONE INTERVIEW SCRIPT

Hi, this is Adelaide calling from the neuropsychology lab at the University of Ottawa. Am I speaking to ____?

I just wanted to call you to go over some important information about the study and confirm whether you are eligible to participate. This should only take about 5 minutes of your time.

First, I'm going to ask you a few screening questions. Is that alright with you?

6. In the screening questionnaire, you said you're currently taking the birth control pill. Is that still the case?
7. Can you please confirm the brand name of the birth control you are currently taking?
8. When approximately did you begin this birth control prescription?
9. Do you take your pill continuously (meaning, do you skip the sugar pill or pill-free week of your cycle)?
10. What was the initial purpose for going on this pill/Why did you begin taking this birth control prescription?
11. Are you thinking of going off the pill or switching prescriptions within the next 3-6 months?

Great, so you are eligible to participate. Thanks for answering these questions again! Now I'll just go over some important information about the study.

In this study we are interested in finding out how using the birth control pill might affect people's memory and other cognitive functions. There are two testing sessions: the first session will take place during one of your sugar pill or pill-free weeks, and the second session will take place 3 months later. So, once you complete the first testing session, we will contact you approximately 2-3 months later to book your second testing session.

The first testing session will last about 1 hour and 25 minutes and you'll be asked to complete some online memory tasks and answer some questionnaires. At the end of the first session, you will receive a \$15 gift card of your choice for your participation. Similarly, the second testing session will last about 1 hour and you will be asked to complete the same tasks and questionnaires as before, and you'll receive a \$30 gift card of your choice.

So far so good?

To prepare for your testing session, you'll need to have a working desktop or laptop with stable internet access. This study is NOT compatible with smartphones or tablets, so please only use your computer. Also, please ensure that you complete the study in one sitting and in a quiet space where you won't be distracted. For some of the tasks, your responses will be recorded, so you will need to have a functioning microphone. Is that ok?

After our phone call, I'm going to send you an email with a link to our calendar. When you click on this link, you'll have to select a date and time to complete your first testing session. Like I mentioned before, we are asking our participants to book their session during one of their sugar pill or pill-free weeks of their cycle. This is because we want to make sure that everyone is in approximately the same phase of their pill cycle when they complete the study. Afterward, you will be sent the study link at the scheduled date and time, along with a couple email reminders about your upcoming testing session. If after you take part in the first session you decide to go off your pill or change birth control prescriptions, please let me know as this would make you ineligible to take part in the second testing session.

Do you have any questions?

EMAIL #2 TEMPLATE

Hello,

Thank you for taking the time to complete the phone interview!

Please click [here](#) to schedule a time to complete the study. As a reminder, please make sure to select a time during the next sugar/placebo pill or pill-free week of your cycle. You will then be sent the study link at the scheduled date and time, as well as reminders about the study.

The day of your online testing session, please follow the steps below:

- A. Complete this study in ONE SITTING
- B. Complete this study on a DESKTOP or LAPTOP with stable internet access (note that this study is only compatible with Google Chrome or Firefox)
- C. Ensure that you are in a quiet space where you will not be distracted
- D. Some of the tasks will require you to speak into your microphone and your responses will be recorded, so please ensure that you have a functioning microphone

Thank you! Please do not hesitate to email us if you have any questions or concerns.

Time 2 follow-up email

ISPR NC PARTICIPANTS

Subject: uOttawa/ISPR study “Let’s test your memory!”: Earn \$30 to participate in Part 2!

Hello,
I hope this email finds you well!

About 3 months ago you participated in the ISPR study called “Let’s test your memory!”. In this study, we were interested in finding out how the menstrual cycle affected memory and other cognitive functions.

You are now invited to participate in part 2 of this study, which involves completing several of the same tasks as before and answering some questionnaires online. This study will last approximately 1 hour, and you will receive a \$30 gift card of your choice (Sephora, Amazon, Starbucks, or Tim Hortons) for your participation.

If you have not taken any form of hormonal birth control within the last 9 months and are interested in taking part in this short study, please follow the instructions below carefully:

Follow these steps to schedule your second online testing session:

- Because we are studying how the menstrual cycle affects memory abilities, we ask that you please complete this study during the first week of your menstrual cycle (i.e., during menstruation/your period).
- Click here to schedule a time during the first week of your next menstrual cycle to complete the study. You will then be sent the study link at the scheduled date and time, as well as reminders about the study.

Follow these steps the day of your online testing session:

- Please complete this study in ONE SITTING
- Please complete this study on a DESKTOP or LAPTOP with stable internet access (note that this study is only compatible with Google Chrome or Firefox)
- Ensure that you are in a quiet space where you will not be distracted
- Some of the tasks will require you to speak into your microphone and your responses will be recorded, so please ensure that you have a working microphone

Thank you! Please do not hesitate to email us if you have any questions.

ISPR CURRENT OC USERS

Subject: uOttawa/ISPR study “Let’s test your memory!”: Earn \$30 to participate in Part 2!

Hello,
I hope this email finds you well!

About 3 months ago you participated in the ISPR study called “Let’s test your memory!”. In this study,

we were interested in finding out how the use of the birth control pill affected memory and other cognitive functions.

You are now invited to participate in part 2 of this study, which involves completing several of the same tasks as before and answering some questionnaires online. This study will last approximately 1 hour, and you will receive a \$30 gift card of your choice (Sephora, Amazon, Starbucks, or Tim Hortons) for your participation.

If you have been taking the same birth control pill for at least 9 months and are interested in taking part in this short study, please read the instructions below very carefully:

Follow these steps to schedule your second online testing session:

- Because we are studying how the birth control pill affects memory abilities, we ask that you please complete this study during the inactive/sugar/placebo pill or pill-free week of your cycle (and NOT during one of the active pill weeks)
- Click [here](#) to schedule a time during the inactive/sugar/placebo pill or pill-free week of your cycle to complete the study. You will then be sent the study link at the scheduled date and time, as well as reminders about the study.

Follow these steps the day of your online testing session:

- Please complete this study in ONE SITTING
- Please complete this study on a DESKTOP or LAPTOP with stable internet access (note that this study is only compatible with Google Chrome or Firefox)
- Ensure that you are in a quiet space where you will not be distracted
- Some of the tasks will require you to speak into your microphone and your responses will be recorded, so please ensure that you have a working microphone

Thank you! Please do not hesitate to email us if you have any questions.

NEW OC USERS

Subject: uOttawa birth control study: Earn \$30 to participate in Part 2!

Hello,

I hope this email finds you well!

About 3 months ago, you participated in our study about how the birth control pill might affect memory and other cognitive functions.

You are now invited to participate in part 2 of this study, which involves completing several of the same tasks as before and answering some questionnaires online. This study will last approximately 1 hour, and you will receive a \$30 gift card of your choice (Sephora, Amazon, Starbucks, or Tim Hortons) for your participation.

If you have been taking the same birth control pill for at least 3 months and are interested in taking part in this short study, please read the instructions below very carefully:

Follow these steps to schedule your second online testing session:

- Because we are studying how the birth control pill affects memory abilities, we ask that you please complete this study during the inactive/sugar/placebo pill or pill-free week of your cycle (and NOT during one of the active pill weeks)
- Click [here](#) to schedule a time during the inactive/sugar/placebo pill or pill-free week of your cycle to complete the study. You will then be sent the study link at the scheduled date and time, as well as reminders about the study.

Follow these steps the day of your online testing session:

- Please complete this study in ONE SITTING
- Please complete this study on a DESKTOP or LAPTOP with stable internet access (note that this study is only compatible with Google Chrome or Firefox)
- Ensure that you are in a quiet space where you will not be distracted
- Some of the tasks will require you to speak into your microphone and your responses will be recorded, so please ensure that you have a working microphone

Thank you! Please do not hesitate to email us if you have any questions.

B3. Informed Consent Forms



uOttawa

Faculté des sciences sociales
Faculty of Social Sciences

INFORMED CONSENT FORM (TIME 1)

Project: Investigating the modulatory effects of oral contraceptives on objective and subjective episodic memory (REB H-11-22-8715)

Principal Investigator: Adelaide Jensen, Ph.D. Candidate; School of Psychology, University of Ottawa.

Thesis supervisor: Dr. Patrick Davidson; School of Psychology, University of Ottawa; (613) 562-5800 ex 2366.

Invitation to participate: I am invited to participate in the abovementioned research study conducted by Adelaide Jensen and Dr. Patrick Davidson.

Purpose of the study: The researchers' goal is to assess how thinking and memory are affected by biological sex and oral contraceptive use. The researchers seek to evaluate scientific hypotheses that males and females, and oral contraceptive users and non-users perform differently from one another.

Participation: During this study, I will be asked to examine different kinds of materials, such as words or pictures, or think about real-life events. Some of these tasks will involve remembering the materials, but others will not. I will be given specific written instructions before each test. The researchers will answer any questions I may have at the end of the session, either in-person or via email. The testing will be in English.

The entire list is:

1. DEMOGRAPHIC QUESTIONNAIRE: This asks background questions about some personal characteristics, menstrual cycle, and oral contraceptive use.
2. CES-D and PANAS: These are brief questionnaires asking about your mood over the past week
3. 10 ITEM PERSONALITY INVENTORY: This is a brief questionnaire assessing your personality traits
4. MULTIFACTORIAL MEMORY QUESTIONNAIRE: This is a short questionnaire assessing how you view your memory ability.
5. TALER STORIES: This is a brief memory test.
6. 4 MOUNTAINS TEST: This is a brief memory test.
7. VERBAL PAIRED ASSOCIATE RECALL: This is a brief memory test.
8. FACE-NAME ASSOCIATIVE RECALL: This is a brief memory test.
9. DIGIT SPAN: This is a brief memory test.
10. MENTAL CONTROL: This is a brief memory test.
11. VERBAL FLUENCY: This is a brief memory test.

The testing will be performed in a single, online session which in total will last approximately 1 hour and 25 minutes. I will have the option to take several short breaks throughout the session. My verbal responses to some of the cognitive tasks will be audio-recorded for scoring purposes.

Compensation: If I am an ISPR participant, I will be given 1.5 ISPR credits for participation. If I am a participant recruited from Prolific or Honeybee, I will be compensated CAD \$15 for my participation. If I am a participant recruited from social media or from the

University of Ottawa campus or health clinic, I will be sent a CAD \$15 e-gift card of my choice. If I choose to withdraw from the study, I will still be compensated the full amount.

Risks: There are no risks associated with participating in this study.

Benefits: Although this research is not designed to aid my case specifically, it will benefit society by providing us with answers about how memory may be affected by biological sex and/or oral contraceptive use.

Confidentiality and Privacy: The information obtained from this study will be presented at scientific conferences or in scientific journals, but my name will never appear in any public document. To ensure confidentiality, my name and other identifying information will be filed separately from the experimental data in our laboratory. The study experimenter will save my email address so that I can be invited to participate in a follow-up testing session in 3 months. My email address will be kept separate from the rest of my data and will only be linked to my unique identification code for the duration of the study.

Conservation of Data: All data collected (from questionnaires, cognitive tasks, and audio recordings) are stored on password-protected computers in our department. The data will be conserved for 7 years after publication, or, if the study is unpublished, 7 years after the end of data collection.

Voluntary participation: My decision to participate in this study is entirely voluntary. I have the right to withdraw from the study at any time and for any reason without penalty or loss of rights (and still receive reimbursement for research participation). If I choose to withdraw from the study, my data will be destroyed immediately along with all identifying information (e.g., email address, age, etc).

It is recommended that I save a copy of this consent form for my records (download link is available on the next page).

Contact Information. If I have any questions or comments on the study, or if I wish a clarification of rights as a research participant, I can contact Adelaide Jensen, Dr. Patrick Davidson, or the Research Ethics Committee at the telephone number and address below.

If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5; Tel.: (613) 562-5387.

Consent to participate:

- ☐ By checking this box, you certify that you have read and understood the information above, and that you have been advised that you are free to withdraw your consent or withdraw from this study at any time without any negative consequence.
- ☐ Check this box if you do not want to participate.



uOttawa

Faculté des sciences sociales
Faculty of Social Sciences

INFORMED CONSENT FORM (TIME 2)

Project: Investigating the modulatory effects of oral contraceptives on objective and subjective episodic memory (REB H-11-22-8715)

Principal Investigator: Adelaide Jensen, Ph.D. Candidate; School of Psychology, University of Ottawa.

Thesis supervisor: Dr. Patrick Davidson; School of Psychology, University of Ottawa; (613) 562-5800 ex 2366.

Invitation to participate: I am invited to participate in the abovementioned research study conducted by Adelaide Jensen and Dr. Patrick Davidson.

Purpose of the study: The researchers' goal is to assess how thinking and memory are affected by biological sex and oral contraceptive use. The researchers seek to evaluate scientific hypotheses that males and females, and oral contraceptive users and non-users perform differently from one another.

Participation: During this study, I will be asked to examine different kinds of materials, such as words or pictures, or think about real-life events. Some of these tasks will involve remembering the materials, but others will not. I will be given specific written instructions before each test. The researchers will answer any questions I may have at the end of the session, either in-person or via email. The testing will be in English.

The entire list is:

1. **DEMOGRAPHIC QUESTIONNAIRE:** This asks background questions about the menstrual cycle and oral contraceptive use.

2. CES-D and PANAS: These are brief questionnaires asking about your mood over the past week
3. 10 ITEM PERSONALITY INVENTORY: This is a brief questionnaire assessing your personality traits
4. MULTIFACTORIAL MEMORY QUESTIONNAIRE: This is a short questionnaire assessing how you view your memory ability.
5. TALER STORIES: This is a brief memory test.
6. 4 MOUNTAINS TEST: This is a brief memory test.
7. VERBAL PAIRED ASSOCIATE RECALL: This is a brief memory test.
8. FACE-NAME ASSOCIATIVE RECALL: This is a brief memory test.

The testing will be performed in a single, online session which in total will last approximately 1 hour and 10 minutes. I will have the option to take a short break halfway through the session. My verbal responses to some of the cognitive tasks will be audio-recorded for scoring purposes.

Compensation: If I am a participant recruited from ISPR, I will be given 1.5 ISPR credits. If I am a participant recruited from Prolific or Honeybee, I will be compensated CAD \$30 for my participation.

If I am a participant recruited from social media or from the University of Ottawa campus or health clinic, I will be sent a CAD \$30 e-gift card of my choice. If I choose to withdraw from the study, I will still be compensated the full amount.

Risks: There are no risks associated with participating in this study.

Benefits: Although this research is not designed to aid my case specifically, it will benefit society by providing us with answers about how memory may be affected by biological sex and/or oral contraceptive use.

Confidentiality and Privacy: The information obtained from this study will be presented at scientific conferences or in scientific journals, but my name will never appear in any public document. To ensure confidentiality, my name and other identifying information will be filed separately from the experimental data in our laboratory.

Conservation of Data: All data collected (from questionnaires, cognitive tasks, and audio recordings) are stored on password-protected computers in our department. The data will be conserved for 7 years after publication, or, if the study is unpublished, 7 years after the end of data collection.

Voluntary participation: My decision to participate in this study is entirely voluntary. I have the right to withdraw from the study at any time and for any reason without penalty or loss of rights (and still receive reimbursement for research participation). If I choose to withdraw from the study, my data will be destroyed immediately along with all identifying information (e.g., email address, age, etc).

It is recommended that I save a copy of this consent form for my records (download link is available on the next page).

Contact Information. If I have any questions or comments on the study, or if I wish a clarification of rights as a research participant, I can contact Adelaide Jensen, Dr. Patrick Davidson, or the Research Ethics Committee at the telephone number and address below.

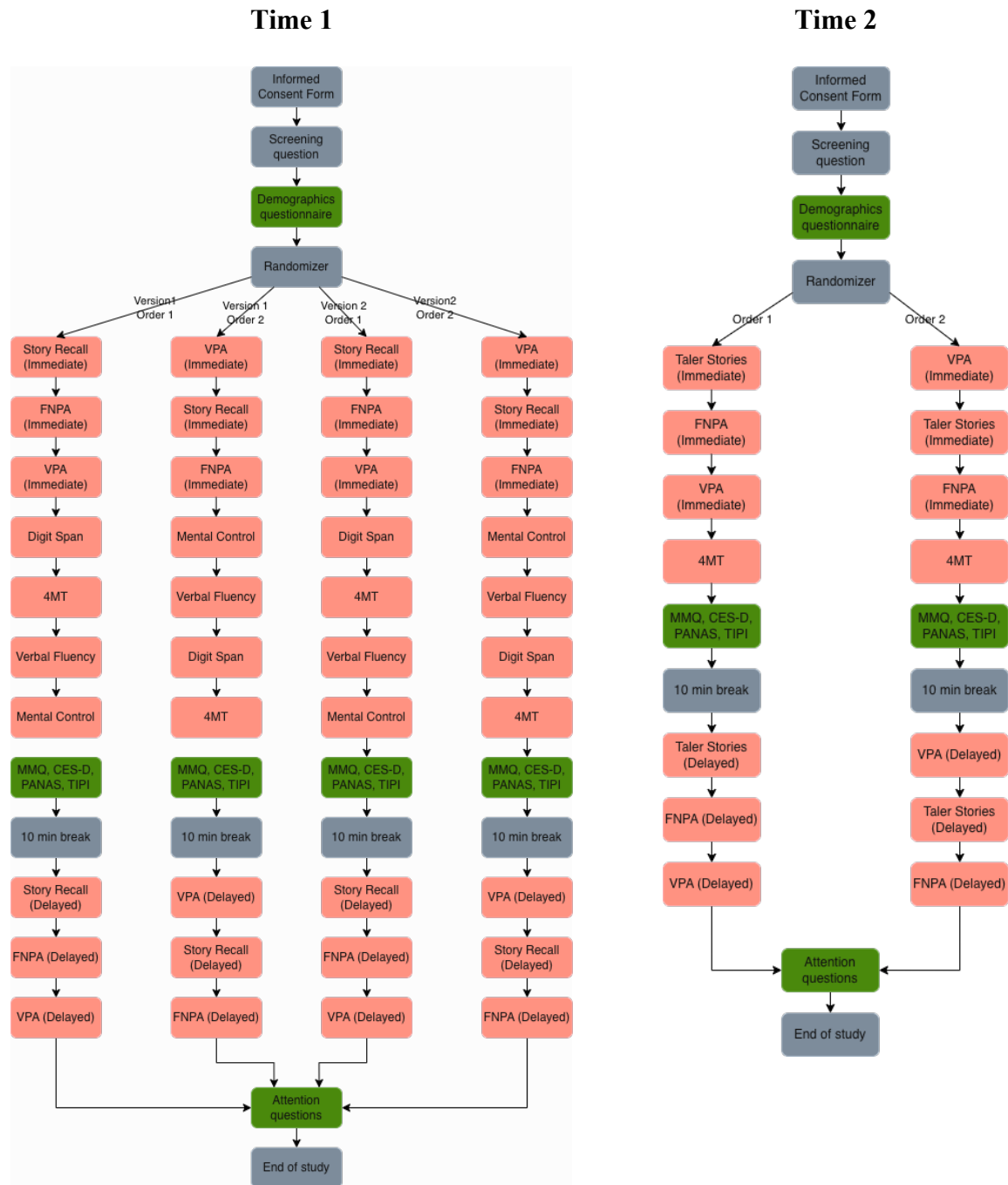
If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5; Tel.: (613) 562-5387.

Consent to participate:

☐ By checking this box, you certify that you have read and understood the information above, and that you have been advised that you are free to withdraw your consent or withdraw from this study at any time without any negative consequence.

☐ Check this box if you do not want to participate.

B4. Study flowcharts



B5. Questionnaires

Qualtrics OC-NC and demographics questionnaire (Time 1)

EmbeddedData

subjectidValue will be set from Panel or URL.

completion_tokenValue will be set from Panel or URL.

Block: Demographics (11 Questions)

Standard: OC (22 Questions)

Standard: NC (19 Questions)

Standard: Future_OC (4 Questions)

Standard: Other medications (11 Questions)

Start of Block: Demographics

ID What is your ISPR participant ID? (If you are not an ISPR participant, please enter "0")

Email1 Please enter your email address:

Email2 Please re-enter your email address:

Age What is your age?

Sex What is your sex at birth?

- ☐ Female (1)
- ☐ Male (2)
- ☐ Other (3)

Skip To: End of Survey If What is your sex at birth? = Male

Gender With which gender identity do you best identify?

- ☐ Man (1)
- ☐ Non-binary (2)
- ☐ Woman (3)
- ☐ You don't have an answer here that describes me. I describe myself as: (4)
-

Education How many years of formal education have you received (starting at and including Grade 1)?

NativeLanguage My first/native language is:

- ☐ English (1)
- ☐ French (2)
- ☐ Other. Please specify: (3) _____

Display this question:

If My first/native language is: != English

LanguageAge If English is not your first/native language, how old were you when you began learning it?

Relationship Which of the following best describes your current relationship status?

- ☐ Dating or in a casual relationship (1)
- ☐ Engaged or married (2)
- ☐ In a serious relationship but not engaged or married (3)
- ☐ Single (4)

Ethnicity Please select the option that best represents how you identify in terms of your ethnicity.

- ☐ Arab (1)
 - ☐ Asian - East (2)
 - ☐ Asian - South (3)
 - ☐ Asian - South East (4)
 - ☐ Black - African (5)
 - ☐ Black - Caribbean (6)
 - ☐ Black - North American (7)
 - ☐ First Nations (8)
 - ☐ Indian - Caribbean (9)
 - ☐ Indigenous/Aboriginal (10)
 - ☐ Inuit (11)
 - ☐ Latin American (12)
 - ☐ Métis (13)
 - ☐ Middle Eastern (14)
 - ☐ Mixed Heritage (15)
 - ☐ White - North American (16)
 - ☐ White - European (17)
 - ☐ I don't know (18)
 - ☐ Other (please specify) (19)
-

End of Block: Demographics

Start of Block: OC

Current_OC Are you currently taking the birth control pill?

- ☐ No (1)
- ☐ Yes (2)

Display this question:

If Are you currently taking the birth control pill? = Yes

Why_OC Why were you initially prescribed your birth control pill? You may select more than one response:

- ☐ To prevent pregnancy (1)
- ☐ To regulate irregular or missing menstrual cycles (2)
- ☐ To manage physical premenstrual symptoms (e.g., abdominal pain, headaches, fatigue, etc.) (3)
- ☐ To help treat a condition such as endometriosis or polycystic ovarian syndrome (PCOS) (4)
- ☐ To help treat acne or other skin problems (5)
- ☐ To help manage premenstrual dysphoric disorder (PMDD) or other depressive symptoms (6)
- ☐ Other. Please specify: (7)
-

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_name What is the brand name of your birth control pill?

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_pill_number How many pills (in total) are in your current birth control packet?

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_pill_cycle How many pills have you taken so far this cycle?

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_active-inactive Was the last pill you took an active pill or an inactive/sugar pill?

☐ Active pill (1)

☐ Inactive pill (2)

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_time1 At what time of day do you usually take your pill?

☐ Morning (before noon) (1)

☐ Afternoon (12-5pm) (2)

☐ Evening (5-10pm) (3)

☐ Nighttime (10pm or later) (4)

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_time2 At what time did you take or will you be taking your pill today? *For example: "2PM"*

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_duration For approximately how long have you been taking this specific birth control prescription? *Please specify if your response is in months or years. For example: "6 months", "2 years", etc.*

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_history1 Have you previously used one or more different kinds of hormonal birth control before the one you are currently taking? This can include another type of birth control pill, hormonal intrauterine device (IUD), vaginal ring, patch, injection, etc.

☐ No (1)

☐ Yes (2)

Display this question:

If Have you previously used one or more different kinds of hormonal birth control before the one you... = Yes

OC_history2 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. When you are finished listing the types of birth control you used, **please leave the next text box blank**.

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of... Displayed

OC_oldHC1 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #1:

Display this question:

If If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which yo... Text Response Is Not Empty

OC_oldHC2 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #2:

Display this question:

If If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the durati... Text Response Is Not Empty

OC_oldHC3 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the**

duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #3:

Display this question:

If If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, please leave the next text box blank. Birth control #3: Text Response Is Not Empty

OC_oldHC4 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it.** If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #4:

Display this question:

If If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, please leave the next text box blank. Birth control #4: Text Response Is Not Empty

OC_oldHC5 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it.** If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #5:

provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #5:

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #6:

OC_oldHC6 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #6:

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #7:

OC_oldHC7 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #7:

provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #7:

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #8

OC_oldHC8 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #8

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #9

OC_oldHC9 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #9

provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #9:

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #10

OC_oldHC10 For each type of hormonal birth control that you have previously used, please list 1) the type of birth control, 2) the approximate age at which you began using it, and 3) the duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #10

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_ageHC At what age did you first begin taking hormonal birth control (of any kind)?

End of Block: OC

Start of Block: NC

Display this question:

If Are you currently taking the birth control pill? = No

NC_MC-YesNo Do you have a menstrual cycle?

☐ No (1)

☐ Yes (2)

Display this question:

If Do you have a menstrual cycle? = Yes

NC_period Are you currently in the menstrual phase of your cycle (i.e., are you currently on your period)?

☐ No (1)

☐ Yes (2)

Display this question:

If Do you have a menstrual cycle? = Yes



NC_length According to your menstrual tracking app or calendar, what is the average length of your menstrual cycle, in days? (For example, "29 days") *Typically, you would count the number of days between periods/menstruation, starting at the first day of your last period and ending at the first day of your next period. If you don't know the answer to this question, please type "0" and move on to the next page*

Display this question:

If If According to your menstrual tracking app or calendar, what is the average length of your menstrua... Text Response Is Displayed

NC_startdate What was the start date of your last period? **Please type your answer in this format: mm/dd/yyyy**

Display this question:

If If What was the start date of your last period? Please type your answer in this format: mm/dd/yyyy Text Response Is Displayed

NC_nextdate What is the expected start date of your next period? **Please type your answer in this format: mm/dd/yyyy**

Display this question:

If Do you have a menstrual cycle? = Yes

NC_currentday According to your menstrual tracking app or calendar, what day are you currently on in your cycle? *For example: "Day 3"*

Display this question:

If Are you currently taking the birth control pill? = No

NC_HC-history1 Have you used one or more kinds of hormonal birth control in the past? This can include the birth control pill, hormonal intrauterine device (IUD), vaginal ring, patch, injection, etc.

☐ No (1)

☐ Yes (2)

Display this question:

If Have you used one or more kinds of hormonal birth control in the past?This can include the birth... = Yes

NC_HC-history2 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. When you are finished listing the types of birth control you used, **please leave the next text box blank**.

Display this question:

If For each type of hormonal birth control that you have previously used, please list 1) the type of... Displayed

NC_oldHC1 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #1:

Display this question:

If If Birth control #1: Text Response Is Not Empty

NC_oldHC2 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #2:

Display this question:

If If Birth control #2: Text Response Is Not Empty

NC_oldHC3 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the**

duration for which you used it. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #3:

Display this question:

If If Birth control #3: Text Response Is Not Empty

NC_oldHC4 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it.** If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #4:

Display this question:

If If Birth control #4: Text Response Is Not Empty

NC_oldHC5 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it.** If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank.** Birth control #5:

Display this question:

If If Birth control #5: Text Response Is Not Empty

NC_oldHC6 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #6:

Display this question:

If If Birth control #6: Text Response Is Not Empty

NC_oldHC7 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #7:

Display this question:

If If Birth control #7: Text Response Is Not Empty

NC_oldHC8 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #8:

Display this question:

If If Birth control #8: Text Response Is Not Empty

NC_oldHC9 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #9:

Display this question:

If If Birth control #9: Text Response Is Not Empty

NC_oldHC10 For each type of hormonal birth control that you have previously used, please list 1) **the type of birth control**, 2) **the approximate age at which you began using it**, and 3) **the duration for which you used it**. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of birth control you used, **please leave the next text box blank**. Birth control #10:

Display this question:

If Do you have a menstrual cycle? = Yes

NC_MC-reg You would describe your average menstrual cycle as:

- ☐ Almost always regular (i.e., you can always predict the start of your period by at least 2 days) (1)
- ☐ More or less regular (i.e., you can usually predict the start of your period, but not always) (2)
- ☐ Irregular (i.e., you can rarely predict the start of your period) (3)
- ☐ I don't know (4)

End of Block: NC

Start of Block: Future_OC

Display this question:

If Are you currently taking the birth control pill? = No

NewOC Are you planning on starting a new birth control pill prescription soon?

- ☐ No (1)
- ☐ Yes (2)
- ☐ I'm not sure (3)

Display this question:

If Are you planning on starting a new birth control pill prescription soon? = Yes

Or Are you planning on starting a new birth control pill prescription soon? = I'm not sure

WhyOC Why are you planning on taking birth control pill? You may select more than one response:

- ☐ To prevent pregnancy (1)
- ☐ To regulate irregular or missing menstrual cycles (2)
- ☐ To manage physical premenstrual symptoms (e.g., abdominal pain, headaches, fatigue, etc.) (3)
- ☐ To help treat a condition such as endometriosis or polycystic ovarian syndrome (PCOS) (4)
- ☐ To help treat acne or other skin problems (5)
- ☐ To help manage premenstrual dysphoric disorder (PMDD) or other depressive symptoms (6)
- ☐ Other. Please specify: (7)

- ☐ I'm not sure. (8)
- ☐ This question does not apply to me. (9)

Display this question:

If Are you planning on starting a new birth control pill prescription soon? = Yes

Or Are you planning on starting a new birth control pill prescription soon? = I'm not sure

Plan_NewOC Please check the statement that best applies to you:

- ☐ I have already seen my doctor about starting a new birth control pill prescription (1)
- ☐ I have scheduled an appointment with my doctor about starting a new birth control pill prescription (2)
- ☐ I have not yet scheduled an appointment with my doctor about starting a new birth control pill prescription (3)
- ☐ Other (please specify): (4) _____

Display this question:

If Are you planning on starting a new birth control pill prescription soon? = Yes

When_NewOC Approximately when are you planning on starting your new birth control prescription? (If you do not know, please enter "I don't know") *Example: "tomorrow", "in 2 weeks", "on November 21st"*

End of Block: Future_OC

Start of Block: Other medications

Q1 Are you currently taking any medication (besides hormonal birth control)?

- ☐ No (1)
- ☐ Yes (2)

Display this question:

If Are you currently taking any medication (besides hormonal birth control)? = Yes

Q2 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank.** Medication #1:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q3 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank**. Medication #2:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q4 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank**. Medication #3:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q5 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank**. Medication #4:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q6 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank.** Medication #5:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q7 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank.** Medication #6:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q8 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank.** Medication #7:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q9 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank**. Medication #8:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q10 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank**. Medication #9:

Display this question:

If If With the exception of any type of hormonal birth control that you might be taking, please list the medications you are currently taking. For each medication, please indicate 1) the type of medicat... Text Response Is Not Empty

Q11 With the exception of any type of hormonal birth control that you might be taking, please list the **medications** you are currently taking. For each medication, please indicate 1) **the type of medication**, 2) **the reason for consumption**, and 3) **the duration of consumption and dose(s)** in the boxes below. If you do not remember all the details, that is ok. Please try to provide as much information as you can. Note: When you are finished listing the types of medications you are using, **please leave the next text box blank**. Medication #10:

End of Block: Other medications

Qualtrics OC-NC and demographics questionnaire (Time 2)**EmbeddedData**

subjectidValue will be set from Panel or URL.

completion_tokenValue will be set from Panel or URL.

Block: Demographics (6 Questions)

Standard: OC (9 Questions)

Standard: NC (9 Questions)

Start of Block: Demographics

Email 1 What is your email address?

Email 2 Please re-enter your email address:

ISPR If you are a participant recruited from ISPR, please enter your 6-digit ISPR ID (If you are not an ISPR participant, please enter "0")

Relationship Which of the following best describes your current relationship status?

- ☐ Dating or in a casual relationship (1)
- ☐ Engaged or married (2)
- ☐ In a serious relationship but not engaged or married (3)
- ☐ Single (4)

Gender With which gender identity do you best identify?

- ☐ Man (1)
 - ☐ Non-binary (2)
 - ☐ Woman (3)
 - ☐ You don't have an answer here that describes me. I describe myself as: (4)
-

End of Block: Demographics

Start of Block: OC

Current_OC Are you currently taking the birth control pill?

- ☐ No (1)
- ☐ Yes (2)

Display this question:

If Are you currently taking the birth control pill? = Yes

Why_OC Why were you initially prescribed your birth control pill? You may select more than one response:

- ☐ To prevent pregnancy (1)
- ☐ To regulate irregular or missing menstrual cycles (2)
- ☐ To manage physical premenstrual symptoms (e.g., abdominal pain, headaches, fatigue, etc.) (3)
- ☐ To help treat a condition such as endometriosis or polycystic ovarian syndrome (PCOS) (4)
- ☐ To help treat acne or other skin problems (5)
- ☐ To help manage premenstrual dysphoric disorder (PMDD) or other depressive symptoms (6)
- ☐ Other. Please specify: (7)
-

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_name What is the brand name of your birth control pill?

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_pill_number How many pills (in total) are in your current birth control packet?

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_pill_cycle How many pills have you taken so far this cycle?

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_active-inactive Was the last pill you took an active pill or an inactive/sugar pill?

☐ Active pill (1)

☐ Inactive pill (2)

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_time1 At what time of day do you usually take your pill?

☐ Morning (before noon) (1)

☐ Afternoon (12-5pm) (2)

☐ Evening (5-10pm) (3)

☐ Nighttime (10pm or later) (4)

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_time2 At what time did you take or will you be taking your pill today? *For example: "2PM"*

Display this question:

If Are you currently taking the birth control pill? = Yes

OC_duration For approximately how long have you been taking this specific birth control prescription? *Please specify if your response is in months or years. For example: "6 months", "2 years", etc.*

End of Block: OC

Start of Block: NC

Display this question:

If Are you currently taking the birth control pill? = No

NC_MC-YesNo Do you have a menstrual cycle?

☐ No (1)

☐ Yes (2)

Display this question:

If Do you have a menstrual cycle? = Yes

NC_length According to your menstrual tracking app or calendar, what is the average length of your menstrual cycle, in days? (For example, "29 days") *Typically, you would count the number of days between periods/menstruation, starting at the first day of your last period and ending at the first day of your next period. If you don't know the answer to this question, please type "0" and move on to the next page*

Display this question:

If According to your menstrual tracking app or calendar, what is the average length of your menstrua... Text Response Is Displayed

NC_startdate What was the start date of your last period? **Please type your answer in this format: mm/dd/yyyy**

Display this question:

If What was the start date of your last period? Please type your answer in this format: mm/dd/yyyy Text Response Is Displayed

NC_nextdate What is the expected start date of your next period? **Please type your answer in this format: mm/dd/yyyy**

Display this question:

If Do you have a menstrual cycle? = Yes

NC_currentday According to your menstrual tracking app or calendar, what day are you currently on in your cycle? *For example: "Day 3"*

Display this question:

If Do you have a menstrual cycle? = Yes

NC_MC-reg You would describe your average menstrual cycle as:

- ☐ Almost always regular (i.e., you can always predict the start of your period by at least 2 days) (1)
- ☐ More or less regular (i.e., you can usually predict the start of your period, but not always) (2)
- ☐ Irregular (i.e., you can rarely predict the start of your period) (3)
- ☐ I don't know (4)

Display this question:

If Are you currently taking the birth control pill? = No

OC_last3months Have you taken the birth control pill at any point within the last 3 months?

☐ No (1)

☐ Yes (2)

Display this question:

If Have you taken the birth control pill at any point within the last 3 months? = Yes

OC_stop_date If you were using the birth control pill within the last 3 months but then stopped, please indicate the **approximate date** when you stopped using your birth control pill. **Please type your answer in this format: mm/dd/yyyy**

Display this question:

If If you were using the birth control pill within the last 3 months but then stopped, please indicate the approximate date when you stopped using your birth control pill. Please type your answer in ... Text Response Is Displayed

OC_stop_why If you were using the birth control pill within the last 3 months but then stopped, please specify the reason(s) why you stopped using your birth control pill by selecting one or more options below:

☐

I was experiencing physical side effects, such as (please specify): (1)

☐

My clinician recommended that I discontinue my birth control pill (2)

☐

I switched to another birth control pill or method (e.g., IUD, patch, vaginal ring, etc) (3)

☐

I had no further need for contraception because I became pregnant or wanted to become pregnant (4)

☐

I had no further need for contraception because my sexual relationship ended (5)

☐

My birth control wasn't right for me because (please specify): (6)

☐

Other (please specify): (7)

End of Block: NC

Center for Epidemiologic Studies Short Depression Scale (CESD-10)

Below is a list of some of the ways you may have felt or behaved.

Please indicate how often you have felt this way during the past week by checking the appropriate box for each question.

	Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	All of the time (5-7 days)
1. I was bothered by things that usually don't bother me.	☐	☐	☐	☐
2. I had trouble keeping my mind on what I was doing.	☐	☐	☐	☐
3. I felt depressed.	☐	☐	☐	☐
4. I felt that everything I did was an effort.	☐	☐	☐	☐
5. I felt hopeful about the future.	☐	☐	☐	☐
6. I felt fearful.	☐	☐	☐	☐
7. My sleep was restless.	☐	☐	☐	☐
8. I was happy.	☐	☐	☐	☐
9. I felt lonely.	☐	☐	☐	☐
10. I could not "get going."	☐	☐	☐	☐

Positive and Negative Affect Schedule (PANAS)

Indicate the extent you have felt this way over the past week.		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 2	Distressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 3	Excited	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 4	Upset	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 5	Strong	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 6	Guilty	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 7	Scared	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 8	Hostile	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 9	Enthusiastic	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 10	Proud	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 11	Irritable	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 12	Alert	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 13	Ashamed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 14	Inspired	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 15	Nervous	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 16	Determined	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 17	Attentive	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 18	Jittery	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 19	Active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 20	Afraid	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

B6. Study preregistration



Effects of oral contraceptive initiation on objective and subjective memory (#261668)

Author(s)

This pre-registration is currently anonymous to enable blind peer-review.
It has 2 authors.

Pre-registered on:

2025/12/02 07:30 (PT)

1) Have any data been collected for this study already?

It's complicated. We have already collected some data but explain in Question 8 why readers may consider this a valid pre-registration nevertheless.

2) What's the main question being asked or hypothesis being tested in this study?

Does initiation of oral contraceptives (OC) significantly change objective and/or subjective memory compared to long-time OC users and/or non-users?

3) Describe the key dependent variable(s) specifying how they will be measured.

Our dependent variables are measured at two separate timepoints, once at baseline (Time 1) and again following a 3-month delay (Time 2) and include:

- 1) Objective verbal episodic memory composite, comprising Verbal Paired Associates (VPA), Face-Name Paired Associates (FNPA), and Story Recall
- 2) 4 Mountains Task (4MT) measuring visuospatial memory (examined separately from verbal tasks as they are not strongly correlated; Jensen et al., 2025)
- 3) Subjective memory ratings on the Multifactorial Memory Questionnaire [MMQ].

Additional variables measured at both timepoints are mood (Center for Epidemiological Studies Depression Scale – 10-item [CES-D]), affect (Positive and Negative Affect Schedule [PANAS]), and personality ratings (Ten-Item Personality Inventory [TIPI]). Executive control (composite score based on Backward Digit Span, verbal fluency, and Mental Control) is also measured at Time 1 only.

Episodic memory and executive control composites will be calculated by either extracting regression-based scores or by averaging z-scores across individual tasks. We will decide in advance and only use one method.

4) How many and which conditions will participants be assigned to?

1) Between-subjects variable (Oral contraceptive use – 3 levels): Each participant will belong to one of 3 groups: new OC users (newOC; i.e., individuals about to begin taking a new birth control prescription), current OC users (cOC; i.e., individuals who have been taking the same birth control pill prescription for 6 months or more), and NC females (NC; i.e., naturally cycling participants who have not taken any kind of hormonal birth control within the last 6 months).

2) Within-subjects variable (Time – 2 levels): Each participant will undergo neuropsychological testing twice, once at Time 1 (baseline) and again at Time 2 (i.e., after a 3-month delay)

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

Cross-sectional analyses:

If there are significant group differences in mood, affect, or first language (by using independent samples t-tests/Chi-squared distributions), we will control for such factors in our cross-sectional neuropsychological analyses.

cOC and NC participants who only completed Time 1 (i.e., dropped out before Time 2) will be compared using t-tests or ANCOVA (if controlling for mood, affect, or first language) on episodic memory and executive control composite scores, subjective memory, and memory retention scores (see below).

Repeated-measures analyses:

If at Time 1 there are significant group differences in mood, affect, or first language, we will also control for such factors in our repeated-measures neuropsychological analyses.

We will conduct mixed ANOVAs (or ANCOVAs, if controlling for mood, affect, or first language) with three between-subject levels (newOC, cOC, NC) and two within-subject levels (Time 1, Time 2) on episodic memory composite scores, 4MT, and subjective memory. We are specifically looking for a Group*Time interaction for newOC on these variables, with an expected slight increase in objective memory scores from Time 1 to Time 2 compared to both control groups.

Both sets of analyses:

At all timepoints, we will compare the amount of information retained between immediate and delayed recall trials for all three verbal memory tasks



(i.e., VPA, FNPA, Story Recall). We will select one of the following options for this analysis in advance:

- a) Use a retention score representing the difference in the amount of information remembered between the immediate and delayed recall trials of each task, calculated as follows: $[\text{Delayed score} / \text{Immediate score}] * 100$
- b) Use mixed ANOVA to look at Group X Time interaction on immediate and delayed memory scores
- c) Use ANCOVA with delayed recall scores as the DV, group as the IV, and immediate recall scores as a covariate (allows us to control for baseline scores whereas option 2 is relative to immediate score variability)

A p-value of .05 will be used for all main analyses, and Holm-Bonferroni correction will be used to correct for multiple comparisons and for any secondary analyses.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

Participants who fail our attention check AND report being distracted/having not paid close attention during the study (in response to a question asked at the end of each testing session) will be excluded from analysis.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

A power analysis simulation using ANOVA_power (https://shiny.ieis.tue.nl/anova_power/) determined that a total sample size of 128 ($n = 42/\text{group}$) would be needed to detect a small-to-medium effect ($\eta^2 = .05$; based on the smallest effect size of interest found in previous studies) with 80% power and $\alpha = .05$ for mixed ANOVA with 3 groups and 2 measurements.

Similarly, a power analysis conducted in G*Power determined that a total sample size of 78 ($n = 26/\text{group}$) would be needed to detect a small-to-medium effect ($\eta^2 = .05$) with 95% power and $\alpha = .05$ for repeated-measures ANOVA with 3 groups and 2 measurements.

Due to constraints with participant recruitment, we will stop data collection once we reach $n = 40/\text{group}$.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

Secondary analyses:

In both cross-sectional and repeated-measures analyses, we will also compare groups on individual episodic memory and executive control task performance using independent samples t-tests and repeated-measures ANOVA (or ANCOVA and repeated-measures ANCOVA if including covariates). Holm-Bonferroni corrections will be applied to all secondary analyses.

In our cross-sectional analyses, we will also look at 1) Pearson correlations between duration of OC use and neuropsychological variables (i.e., objective memory, subjective memory, and executive control), and 2) potential effects of progestin class on neuropsychological variables (using ANOVA) in the cOC group.

For both sets of analyses, groups will be compared on Big Five personality traits (using TIPI).

NC participants will be tested during menses, and cOC users will be tested during the placebo/pill-free week of their cycle (both self-reported). NewOC users will also be tested during menses at Time 1 and during the placebo/pill-free week of their cycle at Time 2.