The Menstruating Mind: Metacognition Across the Cycle

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Can the menstrual cycle impact cognition? Is there a link between the cycle and the mind? ***Dr Nicole D'Amato Caruana*** *set out to answer these questions in her award-winning Ph.D. thesis, offering the future of research a deeper understanding of the connection between biology and cognition.*

At UM, researchers regularly make innovative and intriguing findings that push the confines of what we know to be true. The university's community of thinkers contributes to diverse fields, unearthing new knowledge and bringing fresh yet integral perspectives to phenomena. One such academic visionary is Dr Nicole D'Amato Caruana, whose groundbreaking research study exploring the impact of the menstrual cycle on metacognition won her the Faculty of Media and Knowledge Sciences Outstanding Ph.D. Thesis Dean's Award in 2024.

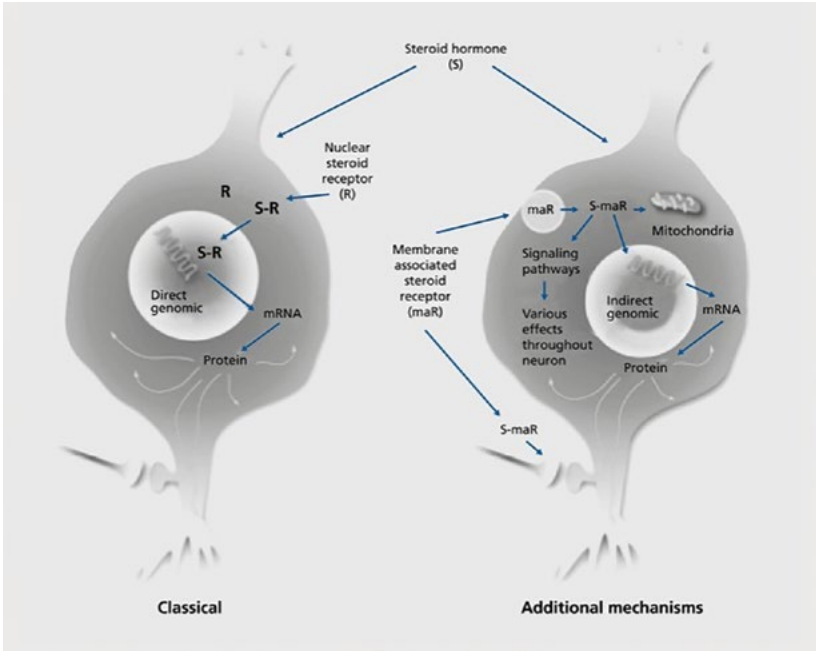
Her study – a juggernaut of scientific and social understanding – is a true game-changer in cognitive research and has weaved an important yet underrepresented perspective into academic discourse. D'Amato Caruana set out to understand how the monthly fluctuation of hormone levels that occurs during the menstrual cycle impacts women's perception of cognitive ability. In doing so, she has helped dismantle common misconceptions and challenged misinformation about how hormonal changes influence the way different women experience and interpret the world.

STARTING THE JOURNEY – WHO IS DR D'AMATO CARUANA?

D'Amato Caruana's Ph.D. journey began after completing her master's degree in cognitive neuroscience at Durham University, UK. She originally assumed she would undertake her Ph.D. studies abroad, but fate drew her back to the Maltese islands when she was offered the opportunity to continue her academic journey at UM. Settling at the Department of Cognitive Science marked a turning point in D'Amato Caruana's career trajectory when she was introduced by her supervisors, Prof. Ian Thornton (Department of Cognitive Science, University of Malta) and Prof. Jeff Kiesner (Department of Developmental Psychology and Socialisation, Università di Padova), to a school of research that explores the relationship between cognition and the cycle.

Dr Nicole D'Amato Caruana

Like many researchers, D'Amato Caruana was drawn to the topic through personal experience. As a scientist living with endometriosis – a chronic condition that affects roughly 10% of reproductive-aged women globally, according to the World Health Organization – 'I've experienced the suffering of the menstrual cycle firsthand, and I wanted to see what I could contribute to the field. That's



Sex hormones binding with brain receptors via genomic and non-genomic mechanisms[1]
Image courtesy of Dr Nicole D'Amato Caruana

what really motivated me to explore this area – it felt both personally meaningful and scientifically important.'

The relevance of understanding the relationship between cognition and the cycle is not to be underestimated. Billions of people worldwide experience the menstrual cycle – a recurring physiological process that is part of the broader menstrual cycle, which involves four phases and various hormonal and physical changes. But as D'Amato Caruana explains, the menstrual cycle is not just biological. There are psychological, societal, and cultural factors that play a role in how a person experiences their cycle, which is unique to each woman.

Hormonal fluctuations across the menstrual cycle are thought to influence cognitive functions such as memory, attention, behaviour, and mood. While many report symptoms such as forgetfulness, confusion, and indecision during certain phases, studies on actual cognitive performance remain inconclusive. Some show effects; others do not. Brain imaging research also presents mixed findings.

One possible explanation is metacognition – how individuals perceive their own cognitive performance – which may help explain the gap between how people feel and how they perform. D'Amato Caruana's goal? To investigate how metacognitive symptoms vary across the cycle, how this differs between individuals, and what biological mechanisms underlie these changes.

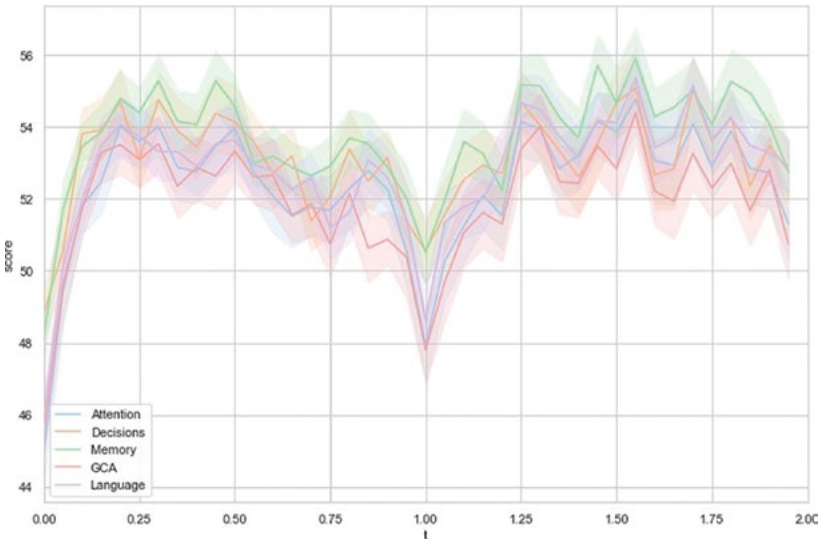
D'Amato Caruana created a research tool specifically for her study: the Daily Online Metacognitive Evaluation – a novel questionnaire that could track the participants' daily cognitive, physical, and affective symptoms throughout two menstrual cycles. Period apps and trackers were also used to chart the participants' different phases through their monthly cycle since everyone's cycle varies. In this systematic way, D'Amato Caruana could observe how menstrual symptoms differ between participants, looking into the individual's experience and providing a deeper insight into the relationship between cognitive, physical, and affective changes that can occur during the menstrual cycle.

QUANTIFYING METACOGNITION AND THE MENSTRUAL CYCLE

Before tackling the core of her research, D'Amato Caruana began with a pilot study to test her methodological approach using both male and female participants. She immediately sensed the gender bias. As individuals who commonly experience the effects of the cycle, it was clear that women were eager for and engaged with this kind of research; as D'Amato Caruana explains, 'if you're going through the experience regularly, you are more invested in understanding its nuances'. Therefore, during the recruitment process, she contacted UM departments that draw in a larger demographic of female students, such as psychology, education, and nursing, to attract participants. In addition to contributing to groundbreaking research, participants were able to receive specialised information unique to their cycle and see how their individual hormone fluctuations impact them personally. D'Amato Caruana's recruitment efforts were successful; she had 120 participants and minimal dropouts along the way, leading to a robust data collection that fuelled her research.

What struck her most was how invested people were in participating

[1] Marrocco, J., & McEwen, B. S. (2016). Sex in the brain: Hormones and sex differences (pp. 374)



Metacognition oscillates in time to the menstrual cycle showing mid-cycle improvement and perimenstrual decline. The figure shows score–time plot for cognitive variables

Image courtesy of Dr Nicole D'Amato Caruana

in the study, despite needing to complete daily questionnaires about their symptoms for two full menstrual cycles – even up to three months of daily monitoring, depending on the length of their cycle. 'This was hard work for the people who took part,' D'Amato Caruana says. 'It was a real commitment. But everyone wants to share their own experience. Everyone wants to tell you what they went through and are suffering from, which is exactly what I was looking into.' The participants' commitment to documenting their daily menstrual experiences shows just how fruitful this kind of research is – not just for women, but also for scientists and scholars eager for data on real-life experiences.

At the end of data collection, D'Amato Caruana could see just how massive the response was – a total of 7,172 questionnaires were collected from participants, and she had the task of sifting through them all! However, despite the gruelling undertaking, D'Amato Caruana believes that the sheer volume of data collection was a significant strength of her research. Using multilevel modelling and structural equation modelling, D'Amato Caruana was able to extract results that clearly captured an effect of the cycle on metacognition: all reported metacognitive abilities declined at the start of the cycle and improved in the middle of the cycle.

Specific cognitive, physical, and emotional symptoms were correlated, suggesting that they may share an underlying biological mechanism, with pathways such as stress-induced inflammation possibly affecting metacognition. D'Amato Caruana also mapped individual differences between participants, echoing Prof. Kiesner's own research findings, shedding light on variations in cyclical changes that reflect the uniqueness of menstruation. 'That's the beauty of it,' D'Amato Caruana relates. 'Everyone is so similar but so different at the same time'.

LOOKING TOWARDS THE FUTURE – ADVICE FOR FUTURE COGNITIVE SCIENTISTS

D'Amato Caruana's study has not only opened the door for future research on the menstrual cycle and metacognition, but also offers an important perspective for academics across various fields. Future research on the menstrual cycle must take individual differences into account, rather than focusing solely on average effects across all women. Given the significant role these differences play, it is essential to consider more personalised approaches to both diagnosis and treatment in women's healthcare. Additionally, the hormonal effects observed in menstruation should open up the conversation on current policies, such as the potential implementation of menstrual leave, to better support those who are affected.

Inspired by her findings, D'Amato Caruana's passion for research continues to grow, driving her to uncover new insights that contribute to human understanding. D'Amato Caruana is currently lending her knowledge to the Research Support Services Directorate (RSSD) at UM, where she works on building the research infrastructure to create a more collaborative and conducive environment for interdisciplinary research to thrive. As an active researcher who continues to explore the unexplored areas of human cognition, D'Amato Caruana's goal is to build on what she achieved with her Outstanding Ph.D. Thesis by advancing knowledge in the field and facilitating larger cross-disciplinary projects that can have far-reaching societal implications.

D'Amato Caruana also has advice for future cognitive science researchers: stay curious and embrace the diversity of the field. 'That's where you'll find unique insights into how the brain works,' she says. 'With cognitive science evolving rapidly and new technologies constantly emerging, gaining hands-on experience through internships, lab work, or independent studies is crucial for the development of practical skills. And if you're considering further study, the master's programme at UM is an excellent choice.'