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When mind and body align: examining the role of cross-modal congruency in conscious representations of happy facial expressions

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ABSTRACT

This study explored how congruency between facial mimicry and observed expressions affects the stability of conscious facial expression representations. Focusing on the congruency effect between proprioceptive/sensorimotor signals and visual stimuli for happy expressions, participants underwent a binocular rivalry task displaying neutral and happy faces. Mimicry was either facilitated with a chopstick or left unrestricted. Key metrics included Initial Percept (bias indicator), Onset Resolution Time (time from onset to Initial Percept), and Cumulative Time (content stabilization measure). Results indicated that mimicry manipulation significantly impacted Cumulative Time for happy faces, highlighting the importance of congruent mimicry in stabilizing conscious awareness of facial expressions. This supports embodied cognition models, showing the integration of proprioceptive information significantly biases conscious visual perception of facial expressions.

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Facial mimicry; facial expressions; sensorimotor simulation; binocular rivalry; visual awareness

Introduction

Embodied cognition, a theoretical framework that emphasises the influence of the body and sensorimotor processes on cognition (Barsalou, 2008; Wilson, 2002), has garnered significant attention in the field of cognitive science. Several studies have demonstrated a noteworthy impact on cognitive domains such as perception, language, and emotion (Gallese & Lakoff, 2005; Niedenthal et al., 2005; Zwaan & Taylor, 2006). Within this context, extensive research has provided evidence suggesting that the observer's facial mimicry, whether visible or imperceptible, and sensorimotor activity contribute to the recognition of others' facial expressions (Caruana & Borghi, 2013; Gallese & Sinigaglia, 2011; Goldman & de Vignemont, 2009; Niedenthal, 2007; Pitcher et al., 2008; Quettier & Sessa, 2023; Wicker et al., 2003).

Before delving into our study's context, it is essential to highlight the rich history of research on mimicry manipulation paradigms. Among the foundational works in this domain is the seminal "pen-holding paradigm" introduced by Strack et al. (1988). In this study, participants held a pen in their mouth in a manner that either facilitated or inhibited the use of facial muscles typically associated with smiling. Results indicated that such subtle facial changes influenced the emotional evaluations of stimuli, underscoring the deep connection between facial mimicry and affective responses. However, it is worth noting that the results from the Strack et al. study have not been without controversy. Subsequent research has produced mixed results, with some studies failing to replicate the original findings (Wagenmakers et al., 2016). A meta-analysis by Coles

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et al. (2019) highlighted the variability in effect sizes across replications. Furthermore, a comprehensive multi-lab replication effort by Coles et al. (2022) found challenges in consistently replicating the original effect, emphasising the need for cautious interpretation of the pen-holding paradigm. Despite these controversies, the paradigm has been influential, and over the years, variations of this method have been employed in various contexts, emphasising the intricate relationship between sensorimotor feedback and cognitive-emotional processes.

Within this theoretical context, a recent study conducted by our research group has provided fresh insights into the impact of bodily signals, by means of the pen-holding manipulation, on visual consciousness. Specifically, this study has revealed the noteworthy role of the observer's facial mimicry in stabilising the conscious perception of facial expressions displayed by others (Quettier et al., 2021). Quettier and colleagues examined the modulation of conscious perception of happy and neutral facial expressions using a binocular rivalry (BR; (Alais & Blake, 2005)) paradigm. The experiment involved inhibiting facial mimicry to investigate its impact on the perception of facial expressions. Participants were instructed to continuously report their conscious experiences throughout the trials. During each trial, participants were presented with a pair of conflicting images, featuring both a neutral and a happy expression of the same individual, using anaglyph glasses. The study compared two conditions: one with unrestricted facial mimicry and another where participants held a chopstick between their lips to restrict the movement of the zygomatic muscles, thereby limiting facial mimicry. This research design allowed to investigate how the inhibition of facial mimicry influenced the conscious perception of facial expressions. The findings shed light on the crucial role played by facial mimicry in stabilising the contents of consciousness when perceiving facial expressions. By analyzing the time series data derived from participants' reports, Quettier and colleagues derived three distinct measures: (1) Initial Percept (IP), representing the first dominant stimulus experienced during a trial, which indicated any potential bias or advantage of one stimulus over the other; (2) Onset Resolution Time (ORT), referring to the time elapsed from stimulus presentation to the detection of the IP; and (3) Cumulative Time (CT), denoting the duration of dominance for each visual percept over its rival. CT provided insights into the stability of a stimulus as the content of awareness.

Quettier et al. anticipated that interfering with sensorimotor signals through inhibition of facial mimicry would have favoured neutral facial expressions and disrupted the perception of happy expressions when compared to conditions with unrestricted mimicry. However, the blocking of facial mimicry had a more selective impact, influencing the perceptual dominance (CT) of neutral faces while leaving the perceptual dominance of happy faces unaffected. No effects were observed for the other measures (IP and ORT), suggesting that the manipulation of mimicry did not affect the time required for the first dominance to be established. To explain this partially unexpected finding, it was suggested that the stabilisation effect may depend on the congruency between sensorimotor facial feedback and the visual representation of facial expressions. When these two types of information are congruent, it enhances the stabilisation of awareness for the expression.

However, the study in question had a notable limitation as it failed to incorporate a crucial manipulation that could provide critical support for the interpretation of the results. Specifically, there was no condition in which mimicry was manipulated to align with the expression of happiness, rather than being antagonistic. A manipulation of this nature, involving the activation of the zygomatic muscle, is instrumental in decisively elucidating the role of congruency as a crucial factor in modulating conscious processing. Incorporating such a manipulation would significantly enhance our understanding of the mechanisms at play and strengthen the conclusions drawn from the study.

The primary objective of our study was to address the aforementioned limitation by introducing a complementary mimicry manipulation and investigating the impact of congruency between this manipulation and observed facial expressions on the stability of conscious contents. By doing so, we aimed to shed light on the cognitive system's ability to selectively integrate or disregard cross-modal and/or accessory information, ultimately influencing the stabilisation of conscious percepts. To ensure a precise understanding of congruency, we adopted the definition proposed by Talsma et al. (2010) within the context of cross-modal integration. According to their definition, congruency refers to the matching of one or more features across stimuli, stimulus components, or stimulus modalities. In the present study, we operationalised congruency as the cross-modal match between a visual representation of a happy facial expression and the somatosensory representation activated through the participant's contraction of the zygomatic major muscle. By utilising this operationalisation, we aimed to provide compelling evidence for the existence of a congruency effect. In this regard, the use of a chopstick manipulation aimed to activate the zygomatic major muscle, associated with the mimicry of the facial expression of happiness (see Figure 1, right panel). Drawing from the findings of Quettier et al., we hypothesised a more pronounced effect on CT than on ORT. This hypothesis is underpinned by the inherent delay in facial mimicry elicitation, which, in reaction to a facial expression, generally spans several hundred milliseconds. Given such a temporal dynamic, it logically follows that facial mimicry's influence would become palpable once the facial expression establishes itself as the prevailing content of visual consciousness. Building on this premise, we postulated that enhancing the proprioceptive/sensorimotor signal via the induction of facial mimicry would extend the CT for happy facial expressions relative to scenarios with free mimicry. The materials, apparatus, measures, and analyses employed in this study are consistent with those utilised by Quettier et al. (2021), apart from the chopstick manipulation and the anaglyph goggles setting (see Method for more details).

Method

Participants

A total of twenty-eight healthy female participants were recruited from the student population at the University of Padova. The average age of the participants was 24.14 years, with a standard deviation of 3.67. Two participants were left-handed. The sample size was determined based on the methodology employed by Quettier et al. (2021), ensuring consistency in the research approach. Detailed information regarding the sample size calculation and effect size estimation can be found at https://osf.io/xk25b/. We calculated the power using the pwr package (Champely et al., 2017) for a paired t-test comparing blocked and free mimicry conditions, based on the estimated effect size of 0.478 (see Coles et al., 2019). Given our specific directional hypothesis regarding mimicry's effect, a sample size of 28 participants would be required to achieve 80% statistical power.

All participants provided written informed consent in accordance with the ethical guidelines outlined in the Declaration of Helsinki. The experimental procedures received approval from the local research ethics committee, specifically the Comitato Etico della Ricerca Psicologica Area 17 at the University of Padua. Participants had normal or corrected-to-normal vision, and their colour vision was assessed using the Ishihara colour blindness test (Ishihara, 1918).

During the experiment, two participants were replaced due to specific circumstances. Participant 1 did not adhere to the instructions regarding the use of anaglyph goggles, while participant 23 had strabismus, which compromised their ability to experience BR.

Upon completion of the experiment, participants were asked to complete two questionnaires, namely the Toronto Alexithymia Scale (TAS-20) developed by Bagby et al. (1994) and the Interpersonal Reactivity Index (IRI) designed by Davis (1983). These

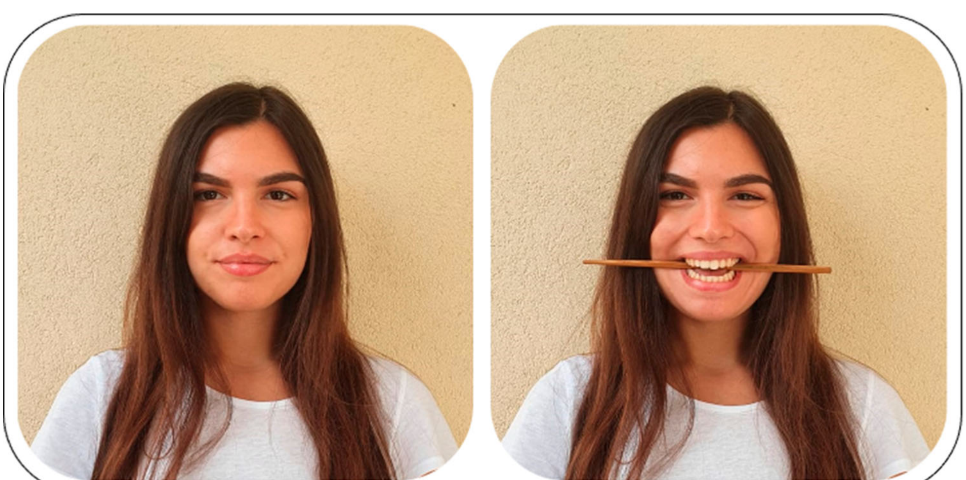

Figure 1. Condition of free mimicry (left) and condition of facilitated mimicry (right).

questionnaires were included to assess participants' ability to identify, understand, and express emotion effectively, which is relevant to our study. The scores obtained from both questionnaires fell within the normal range, with TAS-20 scores averaging at $M = 41.6$ and $SD = 8.96$, and IRI scores averaging at $M = 102.92$ with $SD = 10.97$.

Materials and apparatus

The stimuli and equipment used in this study were consistent with those described in Quettier et al. (2021). Visual stimuli were presented using E-Prime 2.0 Software (version 2.0.10.242; Psychology Software Tools, Pittsburgh, PA) on an LG Flatron F700B monitor (Brightness: 85; Contrast: 90; 85 Hz). Original stimuli were selected from the Karolinska Directed Emotional Faces (Lundqvist et al., 1998) database, featuring one male and one female face each displaying both neutral and happy expressions (AM10NES, AM10HAS, AF01NES, AF01HAS). These visual stimuli, each covering 8 degrees of visual angle in height and width, were created as anaglyphs. In this process, images of the same individual expressing both happy and neutral emotions were superimposed, with the green and red image layers inverted, resulting in two stimuli for each identity.

Procedure

The experimental setup and equipment utilised in this study closely replicated those described in Quettier et al. (2021), ensuring consistency in methodology. Similarly, the same measures and analytical techniques were employed to maintain comparability of results. Following the approach outlined in Korb et al. (2017), participants wore red lens glasses, with the lens positioned over their non-dominant eye. The assessment of eye dominance was conducted using a hole-in-the-card test. Participants were given a card and instructed to hold it with both hands, while looking at a target situated 3 metres away through a hole located in the centre of the card. The eye that provided clear vision of the target through the hole was deemed the dominant eye. During the experiment, participants were asked to focus on a fixation point located in the middle of the screen. The experiment consisted of one session of four blocks. Each participant performed two blocks where they could freely use their facial mimicry and in other two blocks, they were asked to hold a chopstick. To induce a specific modification of facial mimicry known to engage the zygomaticus major muscles and elicit a "standard" smile, participants were instructed to hold a chopstick horizontally between their teeth, as illustrated in Figure 1. The order of the two mimicry conditions was counterbalanced across participants. In each block, four rivalry stimuli were presented in a random order for a total of eight trials (twice per stimulus) in each block. Rivalry stimuli were presented for 15 s preceded by a 2-s fixation point and followed by a 3-s black screen. Participants were asked to code what they saw in real time by pressing one of three keys of the keyboard ("b", "n", "m", these keys are adjacent to each other on the standard keyboard in this order from the left to the right). Participants were informed that on each trial they could see one of two faces, and that the appearance might change from one to the other during the trial. Coding instructions were presented before the beginning of the block; the order of the "b" and "m" keys, corresponding to the coding of the "happy" and "neutral" facial expression, was counterbalanced across blocks, while the "n" key always corresponded to the coding of a "mixed" percept. In the middle and at the end of each block a short break was recommended to the participant to reduce any fatigue. At the end of each mimicry conditions (i.e. two blocks) valence and arousal of each stimulus were measured respectively on a $-3/+3$ and $+1/+7$ scales.

Data reduction and analysis

In the process of data reduction, several measures were derived and analyzed. We initially assessed differences in stimulus ratings for valence and arousal to verify participants' ability to evaluate the emotional content of the stimuli. Secondly, the IP was extracted for each trial, representing the first reported percept of either a neutral or happy facial expression. This enabled an examination of potential changes in the frequencies of initial percepts based on both the emotional content of the face and the mimicry manipulation. Additionally, the onset resolution time (ORT) was computed as the average time taken to code each IP, and a logarithmic transformation was applied for the subsequent analysis. The focus was to determine if there were any significant differences in ORT between conditions (i.e. related IP and mimicry manipulation). Furthermore, cumulative times (CTs) were calculated to assess perceptual predominance separately for mixed percepts, neutral facial expressions, and happy facial expressions. CTs were obtained by summing the duration of each percept segment during a trial.

Moving on to the data analysis, several statistical procedures were employed using R Statistical Software (v3.6.3; R Core Team (2023). To assess the probability of the IP occurring based on the facial mimicry manipulation, a mixed-effects logistic regression model was employed. The model treated IP (happy or neutral) as the dependent variable, while mimicry condition (free vs. manipulated) was included as the explanatory variable. Subjects were considered random effects in the model, accounting for varying intercepts. The odds ratio between the free and manipulated conditions was used to evaluate the effect of mimicry on the likelihood of the IP. For the investigation of the impact of the mimicry manipulation (free vs. manipulated) and emotional contents on all other measures (Valence, Arousal, ORT, CTs), we conducted separate ANOVAs and followed them with subsequent post hoc comparisons to control for multiple comparisons. To address the issue of multiple comparisons, we applied Bonferroni correction.

Results

Valence and arousal ratings

Valence and arousal evaluations were conducted for individual stimuli at the conclusion of each mimicry condition block (i.e. two blocks). As anticipated, for valence ratings, a mimicry condition x emotion ANOVA yielded a significant main effect of emotion, $F(1, 27) = 526.69$, $p < .001$, $d = 8.83$. Neutral facial expressions received ratings close to zero ($M = -1.07$; $SD = 0.83$; range = −3 to 3), indicating a slightly negative valence. In contrast, happy facial expressions were rated more positively ($M = 2.48$; $SD = 0.49$; range = −3 to 3) compared to neutral expressions. There was no main effect for mimicry manipulation, $F(1, 27) = 2.2$, $p = .15$, or interaction between mimicry manipulation and emotion, $F(1, 27) = 0.19$, $p = .66$. (Table 1)

Regarding arousal ratings, they also exhibited expected differences, a mimicry condition x emotion ANOVA yielded a significant main effect of emotion, $F(1, 27) = 96.34$, $p < .001$, $d = 3.78$. Neutral facial expressions received lower arousal ratings ($M = 2.43$; $SD = 1.16$; range = 1–7) compared to happy facial expressions ($M = 5.27$, $SD = 1.2$; range = 1–7). There was no main effect for mimicry manipulation, $F(1, 27) = 0.5$, $p = .81$ or interaction between mimicry manipulation and emotion, $F(1, 27) = 0.5$, $p = .82$.

Table 1. Valuation of stimuli arousal and valence. Valence and arousal of each stimulus were measured respectively on a −3/+3 and 1/7 scales.

		Valence		Arousal	
Mimicry	Emotion	Mean	SD	Mean	SD
manipulated	happy	2.54	0.49	5.30	1.26
	neutral	−0.97	0.87	2.44	1.02
free	happy	2.44	0.51	5.25	1.17
	neutral	−1.17	0.80	2.43	1.32

Binocular rivalry metrics

The statistical models for both initial percept (IP) and onset resolution time (ORT) included the factor of mimicry (free vs. manipulated). Additionally, in the case of ORT, we also considered the first reported clear facial expression (IPs; happy vs. neutral). This inclusion of facial expression aligns with the resolution of ambiguity between rivalrous percepts. For the cumulative time (CT) metric, the statistical model included the factors mimicry (free vs. manipulated) and the reported content (happy vs. neutral vs. mixed).

In terms of IPs, happy expressions were reported more frequently in both mimicry conditions (manipulated: 302 trials; free: 281 trials) than neutral expressions (manipulated: 143; free: 160). However, the odds ratio was not statistically significant ($\beta = 0.190$, SE = 0.144, 95% CI [−0.09, 0.47], $t = 1.32$, $p = 0.187$). Regarding ORT, a mimicry condition x IP ANOVA did not yielded a significant main effect of mimicry ($F(1,26) = 0.046$, $p = 0.831$, d = 0.08) or interaction ($F(1,26) = 0.05$, $p = 0.831$, $d = 0.08$). However, a significant main effect of the first clear reported content was found ($F(1,26) = 42.13$, $p < .001$, $d = 2.55$), indicating that happy faces exhibited an advantage over neutral faces in terms of ORT, consistent with prior literature (Alpers & Gerdes, 2007; Quettier et al., 2021; Yoon et al., 2009). Overall, ORT analyses did not support the influence of mimicry on the early stage of resolution of ambiguity, indicating that zygomatic muscle facilitation did not significantly affect the resolution of ambiguity in favour of happy facial expressions ($t(26) = -0.50$, $p = 0.62$, $d = -0.2$, BF10 = 0.22) or at the expense of neutral facial expressions($t(26) = 0.002$, $p = 0.99$, $d = 0.001$, BF10 = 0.2), consistent with Korb et al. (2017). See Figure 2.

With regard to CTs, a mimicry condition x emotion ANOVA yielded a significant main effect of emotion, ($F(1.84, 49.86) = 51.95$, $p < .001$, $\eta^2 = 0.66$). CT for happy facial expressions had a longer duration compared to

CT for neutral faces ($t(27) = 7.19$, $p < .001$, $d = 2.77$) and mixed percepts ($t(27) = 8.84$, $p < .001$, $d = 3.40$), in line with previous findings (Alpers & Gerdes, 2007; Quettier et al., 2021; Yoon et al., 2009).

The main effect of mimicry did not yield a significant effect ($F(1, 27) = 1.47$, $p = 0.235$, $d = 0.47$). Specifically, it was anticipated that CT for happy facial expressions would increase when mimicry was congruent with the happy expression (facilitated mimicry condition: $M = 7.15$ s; $SD = 4.73$ s; free mimicry condition: $M = 6.83$ s; $SD = 4.85$ s), while CT for neutral faces would not be affected by mimicry manipulation (facilitated mimicry condition: $M = 3.66$ s; $SD = 3.81$ s; free mimicry condition: $M = 3.84$ s; $SD = 3.92$ s). This observation was supported by a significant interaction between mimicry manipulation and the reported content ($F(1.82, 49.19) = 3.83$, $p = 0.032$, $\eta^2 = 0.12$). Consistent with our expectations, the interaction was primarily driven by the modulation of CTs for happy expressions based on the mimicry manipulation, showing longer CT in the facilitated mimicry condition compared to the free mimicry condition ($t(27) = 3.35$, $p = 0.002$, $d = 1.29$). The Bayes factor provided strong evidence (BF10 = 15.54) in favour of the alternative hypothesis H1. Post-hoc comparisons for neutral and mixed percepts did not yield significant results ($t(27) = -0.6$, $p = 0.555$, $d = 0.23$, BF01 = 4.35; $t(27) = -1.59$, $p = 0.122$, $d = 0.61$, BF01 = 1.61, respectively). Notably, substantial evidence in favour of the null hypothesis H0 for neutral faces suggests the robustness of the observed findings. See Figure 3 for visual representation.

Discussion

In building upon the insights from Quettier and colleagues (2021), our study was rooted in the question of how congruency between proprioceptive/sensorimotor signals (specifically, activation of the zygomatic major) and observed facial expressions (especially, happy faces) might stabilise conscious facial representations during BR. To this end, participants engaged in a BR task presenting rivalrous happy and neutral faces, with facial mimicry either facilitated by a chopstick-held contraction or left free.

Our central assumption was that if the integration of facial proprioceptive signals with visual perception occurs predominantly during the later processing stages – specifically, once the facial stimulus has become the dominant content of visual consciousness – then enhancing facial mimicry should have a pronounced impact on the CT for happy faces. In other words, this would lead to an increased duration of happy faces being stably perceived as the dominant content in awareness. A further distinction we underscored was that we did not expect the zygomatic activation to stabilise neutral facial expressions, given the incongruence between the proprioceptive signal from zygomatic contraction and a neutral

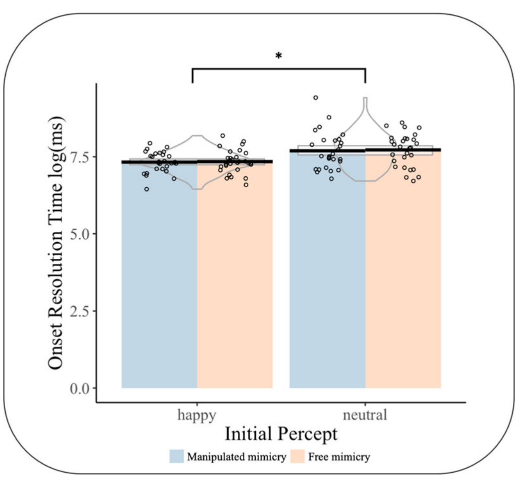

Figure 2. Main effect of relative IP on ORT. Coloured bars show central tendencies. Rectangles, beans, and points represent confidence intervals, smoothed densities, and participants' mean data, respectively. * $p < .05$, ** $p < .01$, *** $p < .001$.

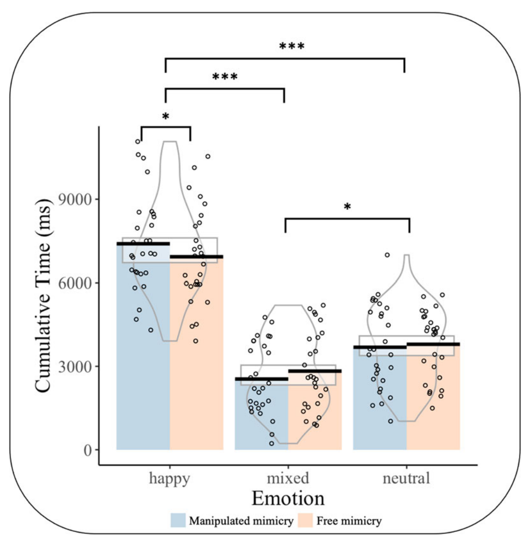

Figure 3. Main effect of emotion and interactions with mimicry for CT. Coloured bars show central tendencies. Rectangles, beans, and points represent confidence intervals, smoothed densities, and participants' mean data, respectively. * $p < .05$, ** $p < .01$, *** $p < .001$.

facial perception. To dissect these nuances, we employed a Bayesian approach, emphasising evidence for our experimental hypothesis with happy expressions and the null hypothesis for neutral ones. This methodology ensured a robust framework to elucidate our results in the context of the study's foundational hypotheses. Our analyses, indeed, revealed significant effects of the interaction between reported content (happy, neutral, and mixed percepts) and mimicry manipulation on the cumulative time. Further examination of the data provided evidence that the CT for happy faces increased when facial mimicry was facilitated compared to when participants were free to engage in facial mimicry. Mimicry manipulation did not affect CT for neutral faces. These results, combined with previous evidence (Quettier et al., 2021), suggest that congruency between the experimental manipulation of facial mimicry and the observed facial expression plays a crucial role in stabilising content in awareness.

The concept that congruency between "information" can influence conscious processing has gained attention and has also been interpreted within the theoretical framework of predictive processing. Predictive processing proposes that the brain continually generates and updates predictions about incoming sensory information using principles of Bayesian inference (Clark, 2012; Friston et al., 2005; Hohwy, 2013; Seth, 2014). By incorporating the concept of congruency within this framework, we can explore how the brain's predictive mechanisms interact with congruent information to shape conscious perception. Empirical evidence supports the idea that perceptual predictions and expectations strongly affect conscious perception (Hock et al., 1993; Kanai & Verstraten, 2005; Kleinschmidt et al., 2002; Williams et al., 1986), providing concrete examples of how prior expectations and congruent information can influence conscious perception.

To comprehend the role of congruency in conscious processing, it is essential to investigate under which circumstances congruency between information can facilitate access to consciousness and/or stabilise the conscious content that has already gained access. Our results suggest that, in the specific context of integrating visual information of a happy facial expression with congruent somatosensory information, the latter does not affect the speed of conscious access to visual information but rather contributes to its stabilisation in consciousness, as indicated by the pattern of results related to onset resolution times/initial percepts vs. cumulative times.

To account for the absence in our study of direct influence of somatosensory information on the initial conscious access of visual information, we can turn to the principle known as "modality appropriateness" in the field of multisensory integration (Welch & Warren, 1980). According to this principle, certain stimulus characteristics are processed with greater accuracy in one sensory modality compared to another. Consequently, in the integration process, the information processed by one modality tends to dominate over that of another modality (e.g. visual information over somatosensory information; (Spence, 2011)). In our specific case, visual information pertaining to facial expressions is likely to exert preeminence over somatosensory information, which integrates later, provided it is congruent. This indicates that visual processing takes precedence over somatosensory processing in terms of speed and influence. Moreover, in ecological contexts, an observer's facial mimicry, which involves the subconscious imitation or mirroring of others' facial expressions, typically follows the perception of a facial expression. Although this phenomenon can occur rapidly within a few hundred milliseconds of perceiving the facial expression, it implies that there is a temporal directionality in the associative link between visual and proprioceptive information. Visual information is initially processed, with somatosensory information pertaining to the possible facial mimicry being processed immediately thereafter. This observation helps explain why the manipulation of facial mimicry in our study affected the stabilisation of conscious contents rather than conscious access. The sequential processing of visual and somatosensory information suggests that the modulation of somatosensory inputs through facial mimicry influences the stabilisation of conscious percepts once the initial visual processing leading to consciousness has occurred.

In wrapping up our discussion, we acknowledge an essential facet that warrants consideration and further exploration in future research. While our study builds upon the foundational "pen-holding paradigm" introduced by Strack et al. (1988), it is pertinent to recognise the debates surrounding its validity. There is a pressing need for researchers to understand under which conditions the pen-holding paradigm exerts an effect and when it does not. For instance, our study exclusively comprised female participants, which raises the possibility that gender could modulate the impact of this paradigm. Furthermore, as illustrated in Figure 1, our manipulation was distinctively marked, ensuring that the pen profoundly activated the zygomatic muscle. Notwithstanding these considerations, our findings provide a robust positive example, emphasising the potential and continued relevance of such mimicry manipulation techniques in understanding the interplay of facial expressions and cognitive processes, here specifically visual consciousness of happy facial expressions.

In conclusion, our findings strongly support the principles of embodied cognition and emotion models, highlighting the close interplay between cognitive processes and bodily experiences. The results provide compelling evidence that the manipulation of facial mimicry has a selective influence on the stabilisation of conscious representations of facial expressions in BR tasks. Importantly, our study goes beyond this by shedding light on the intriguing impact of congruent sensorimotor information on conscious visual perception of facial expressions. This novel insight adds a crucial dimension to our understanding of how bodily responses and perceptual processes interact to shape conscious perception. By demonstrating the role of congruency in modulating conscious visual experiences, our research contributes to a deeper comprehension of the intricate relationship between embodiment, emotion, and conscious awareness.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Authors' note

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Author contributions

P.S. and T.Q. developed the study concept. All the authors contributed to the study design. T.Q. programmed the experiment and prepared the stimuli. T.Q. and E.M. gathered the data. T.Q. performed the data analysis, and P.S., T.Q., and N.T. interpreted the data. T.Q. and P.S. drafted the manuscript, and N.T. provided critical revision. All the authors approved the final version of the manuscript.

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