Advances in Psychology 心理学进展, 2020, 10(2), 92-100
Published Online February 2020 in Hans. http://www.hanspub.org/journal/ap
https://doi.org/10.12677/ap.2020.102012

Hans汉斯

The Role of Facial Identity and Expression in Memory Superiority Effect of the Threatening Face

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Received: Jan. 14th, 2020; accepted: Jan. 29th, 2020; published: Feb. 5th, 2020

Abstract

Human face plays an important role in social activities, and the advantage of memory for threatening faces can help us avoid risk and adapt to the environment. Faces can convey threat messages through facial identity and facial expressions. Threatening identity indicates that the person is a long-term threat to others, while threat expression indicates that the person may be a temporary threat. According to several important factors that affect memory, revealing the behavior and neural mechanism of threat face processing is the key to understand memory advantage of the threatening face, and is also an important problem in psychological research. Recent behavior, brain imaging, and ERPs studies have revealed the memory advantage of threatening faces is mainly due to the attention and perception advantage in the face coding process, and is embodied in the process of the threatening identity and threatening facial expression. In comparison with non-threatening face memory, it is found that threat face memory has a unique neural processing mechanism dominated by amygdala, superior temporal sulcus, orbito frontal cortex and insula. Specifically, studies of the identity of threatening faces have found that faces of both defectors and untrustworthy individuals have a memory advantage. The reason could be that remembering the threatening people is more important for self-protection and is rare in life. At the same time, the research of neural mechanism shows that the face with threatening identity will attract more attention, and the recognition of the face will spontaneously recall the information related to the threat identity, with greater activation of the anterior paracentric gyrus, superior temporal sulcus, and insula. Studies of the emotionally threatening faces have found that such faces have higher processing efficiency and quality, and looser recognition response criteria. Compared with an unthreatening face, it is found that threatening emotional face memory has a unique neural processing mechanism including amygdala—anterior cingulate gyrus network and insula. The ERPs studies found that threat emotion faces had larger amplitude on N2pc, P1, and P300 components, indicating that threat expression enhanced the attention bias of threat faces through attention capture and attention maintenance. Due to the different attention to identity and facial expression, the results of relevant literature are relatively scattered. Nevertheless, we can explain the memory advantage effect of the threatening identity and threatening facial expression from the perspectives of evolutionary dominance hypothesis

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文章引用: 孙雨薇, 齐玥, 刘勋(2020). 身份和情绪在威胁面孔记忆优势中的作用. *心理学进展, 10(2),* 92-100.
DOI: 10.12677/ap.2020.102012

and emotional arousal hypothesis. According to the evolutionary hypothesis, the evolutionary pressure has shaped the automatic threat detection system, and the direct-driven, bottom-up and automated attention capture advantage of the threatening faces leads to the memory advantage of threat faces. While emotional hypothesis suggests that the threatening face can quickly enter the arousal system and improve the individual arousal level, thus improving the effort and efficiency in the task process. That is to say, threat faces improve the processing efficiency by improving the arousal level of individuals, and allocate attention resources to more important threat faces through the top-down meaning assessment system, so as to promote the memory of threat faces. Previous studies have confirmed that the superior memory effect of threatening faces is reflected in two aspects, face identity and facial expression. And this memory advantage can be derived from the aspects of threatening face attracting attention, having higher perceptive discernibility, significance and so on. The future research is encouraged to clarify if the relationship between facial expression and facial identity is independent or interactive, consider the differences between instant and potential threatening faces, and distinguish the different stages of memory and the role of emotional and perceptual factors during threatening face processing. Using a variety of technical means and a unified research paradigm will be helpful to observe the cognitive and neural mechanisms behind the threatening face memory advantage.

Keywords

Threatening Emotion, Face Identity, Facial Emotion, Memory, Neural Mechanism

身份和情绪在威胁面孔记忆优势中的作用

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收稿日期：2020年1月14日；录用日期：2020年1月29日；发布日期：2020年2月5日

摘　要

面孔在社会交往中发挥重要作用，人类对威胁面孔的记忆优势能帮助我们更好地规避风险、适应环境. 根据影响记忆的几个重要因素，揭示威胁面孔加工的行为和神经机制是理解威胁面孔记忆优势的关键，也是心理学研究的重要问题。目前的行为研究探讨了威胁面孔的记忆优势主要源自编码阶段的注意和知觉优势；神经机制研究揭示了威胁面孔的记忆优势在威胁身份面孔和威胁表情面孔加工中的体现。与非威胁面孔记忆的比较研究发现，威胁面孔记忆有着独特的以杏仁核、颞上沟、眶额叶和脑岛为主的神经加工机制。未来研究需要考虑不同的威胁种类，区分记忆的不同阶段以及情绪和知觉因素在其中发挥的作用，并尝试采用多种技术手段来探索威胁面孔记忆优势背后的认知神经机制，有助于进一步完善本领域的研究。

关键词

威胁情绪，面孔身份，面孔表情，记忆，神经机制

1. 引言

对环境中的威胁信息做出快速识别和准确记忆是生物的本能之一。威胁信息的自动化加工使个体能够迅速做出逃跑或攻击的决定，从而提高生存概率(Boyer & Bergstrom, 2011)。不同于一般性的威胁刺激(如蛇、电击等)，人类在日常生活中面对的威胁主要来自于社会环境，这种威胁的传达方式之一就是他人的面孔。威胁面孔是指通过表情、身份等传递了威胁性社会信息的面孔。常见的威胁性社会信息有两种：一种是即时威胁，此类威胁即刻发生并产生伤害，常来自于社会成员的攻击或敌意。即时威胁面孔表达了对目标个体的即时威胁和直接反对，是一种传达强烈敌意或支配地位的社会信号(Arne, 1986)，如嫌疑犯面孔、愤怒面孔。另一种是潜在威胁，这种威胁不一定立即发生或产生伤害，常来自于疾病或他人所处环境间接对个体产生的危害。潜在威胁面孔表达了对目标个体直接或间接的潜在威胁和回避，如传染病面孔、恐惧和厌恶面孔(Vermeulen, Godefroid, & Mermillod, 2009; Whalen, 1998)。

威胁面孔的记忆优势，是指人们对威胁面孔的记忆成绩优于其它面孔，从而表现出记忆加工的优势(Thomas, Jackson, & Raymond, 2014)。在每天加工的众多面孔中，威胁面孔会引发更有效的记忆编码，并在面孔再次出现时促进适应性反应。换言之，人们通过记住具有威胁的面孔从而做好充足的应对准备，如记住骗子的面孔以提高警惕以防上当受骗，记住愤怒的面孔以针对性预测该个体的后续行为并做好相应准备。以往的大量研究发现，人们对不同威胁情绪的面孔形成了不同的记忆优势。比如，愤怒面孔视觉短时记忆的记忆容量更大(Jackson, Wu, Linden, & Raymond, 2009)，恐惧面孔的源记忆存在优势(Davis et al., 2011)。然而，现有研究多关注面孔表情所传达的威胁信息，较少关注面孔身份的意义。比如，与记忆厌恶表情面孔类似，当人们记忆厌恶行为者的中性情绪面孔时，也会激活脑岛(Todorov, Gobbini, Evans, & Haxby, 2007)。这表明身份与情绪对面孔记忆加工的影响是相关联的，个体的威胁身份同样导致了对其面孔的记忆优势。为了更清晰地梳理目前较为分散的研究结果(Righi, Gronchi, Marzi, Rebai, & Viggiano, 2015; Shimamura, Ross, & Bennett, 2006)，本文将从面孔身份和面孔表情两种威胁信息来源分析威胁面孔记忆优势的认知神经机制，并阐述相关的理论依据。

2. 威胁身份对面孔记忆的影响

2.1. 行为证据

在实验室中，研究者为陌生面孔赋予“欺骗者”的威胁身份。比如，Mealey，Daood 和 Krage (1996)据行为描述将面孔分为可信、中性和不可信三类，要求被试评价每张面孔的吸引力，并在一周后进行面孔再认。结果发现，不可信面孔吸引力更低，但具有更高的再认准确率。Oda (1997)采用囚徒困境博弈(Prisoner’s Dilemma Game，PDG)范式，向被试呈现搭档的面孔图片，这些面孔图片被随机贴上“背叛者(坦白)”或“合作者(沉默)”标签。同样发现，背叛者的面孔在一周后的测试中再认准确率更高。Yamagishi，Tanida，Mashima，Shimoma 和 Kanazawa (2003)通过拍摄囚徒困境博弈中真实的合作者和欺骗者面孔照片进行再认实验。结果发现，欺骗者的面孔同样比合作者面孔具有更高的再认准确率。无论是真实的欺骗者，还是背叛者标签，都可能会在未来的社会交往中更可能产生欺骗行为，给个体带来更大的威胁，从而引发了威胁面孔记忆优势。

为了进一步探究人们会更好地记住具有威胁身份的面孔的原因，研究者们提出具有威胁身份的面孔更加重要且稀有的解释。Dan 等人(2004)在实验中描述对手的行为，让被试根据描述判断对方的身份是欺骗者、合作者或中性，随后判断记住这张面孔的重要性。结果发现，记住欺骗者重要性的评分高于合作者以及中性身份面孔。进一步的实验发现，被试在编码阶段对欺骗者面孔的注视时间更长，进而导致了对欺骗者面孔的记忆成绩更好。这一结果说明，人们认为记住威胁身份面孔更加重要，因此在编码阶段付出了更多努力。为验证威胁面孔本身重要性，还是威胁信息的罕见度产生了威胁面孔的记忆优势，Barclay (2008)在信任博弈(Trust Game)中以三种比例(2:8，5:5，8:2)呈现合作者和欺骗者面孔，随后进行面孔再认。结果发现，人们只对出现比例少的面孔存在记忆优势，而与面孔本身是否具有威胁身份无关。该结果表明，人们对威胁面孔的记忆优势可能是因为，在社会交往中威胁面孔相比于其它面孔较为少见，记住罕见的威胁面孔会更为高效。

遗憾的是，现有行为研究多以欺骗、背叛等威胁面孔身份为主，缺乏传染病、暴力犯等不同类型威胁身份的研究。威胁身份对于面孔记忆优势的普遍性仍值得进一步研究。

2.2. 神经机制

目前针对威胁身份的面孔记忆研究主要是从个体行为和面孔评价的角度出发，采用情绪中性面孔作为实验材料，分离了威胁表情与威胁身份面孔的记忆，结果发现威胁身份面孔会自动诱发威胁情绪体验，并伴随更多的注意资源分配。Todorov 等人(2007)发现人们会自发回忆与面孔相匹配的行为描述，并伴随前旁扣带回(anterior paracingulate cortex，APC)和颞上沟(superior temporal sulcus，STS)更大的激活，其中与厌恶行为配对的面孔在前脑岛(anterior insula)会产生更高的激活。前旁扣带回和颞上沟与对他人特征和意图判断有关(Gallagher & Frith, 2003; Harris, Todorov, & Fiske, 2005; Mitchell, Banaji, & Macrae, 2005; Winston, Strange, O'Doherty, & Dolan, 2002)，这两个区域的激活表明被试再认面孔时，会自发回忆面孔的身份特征，且该自发的回忆与特定威胁信息相关联。此外，人们在编码不可信面孔时会伴随右侧脑岛激活，这暗示着个体在面对具有威胁身份的中性情绪面孔时可能产生类似厌恶情绪的加工模式，同时编码过程中双侧海马的激活程度可以预测后续对不可信面孔的成功记忆(Tsukiura, Shigemune, Rui, Kambara, & Kawashima, 2013)。脑电研究也发现，人们在加工威胁身份(如罪犯)面孔时，会诱发顶叶更强的 P300 成分波幅(Lefebvre, Marchand, Smith, & Connolly, 2007)，这意味着相比于普通身份的面孔加工，威胁身份面孔的加工会吸引更多的注意资源。

进一步研究发现，面孔身份会优先于面孔表情影响威胁面孔的记忆。Vrtička 等人(2011)将面孔身份和面孔表情结合，发现再认“敌人”的面孔会比“朋友”的面孔在梭状回、杏仁核，以及与动机控制相关的前扣带回产生更大的激活。这意味着提取阶段的面孔加工会受到该面孔威胁身份记忆自上而下的调控，即“敌人”所代表的威胁情绪信息激活了杏仁核(amygdala)和前扣带回(anterior cingulate cortex，ACC)，进而影响左侧梭状回(fusiform gyrus)的激活，产生威胁面孔的记忆优势，这一过程与面孔本身的表情是高兴或是愤怒无关(Vrtička, Andersson, Sander, & Vuilleumier, 2009)。这暗示了威胁身份和情绪对于面孔记忆的影响层级可能存在差异，且威胁面孔的记忆优势可能源于对威胁信息自上而下的调节。

3. 威胁表情对面孔记忆的影响

3.1. 行为证据

研究者们在实验中常采用愤怒、厌恶与恐惧面孔，探讨威胁面孔表情的记忆优势，并发现威胁面孔表情可能从两个方面影响面孔记忆。一是威胁面孔有更高的加工效率和质量。Sessa，Luria，Gotler，Jolicoeur 和 Dell'acqua (2011)使用延迟匹配任务发现，恐惧面孔比中性面孔的辨别力更高、工作记忆容量更大。

Becerril 和 Barch (2011)采用面孔 2-back 任务，同样发现恐惧面孔相比于中性面孔的判断正确率更高，反应时更短。Jackson 等人(2009)通过面孔再认任务发现，愤怒面孔短时记忆的准确率和记忆容量都显著高于高兴和中性面孔。二是对威胁面孔的再认具有更宽松的反应标准。Johansson 和 Mecklinger (2004)采用回忆/知道范式(Remember/Know/Guess paradigm)，发现威胁情绪面孔(愤怒、恐惧、厌恶)的正确再认主要基于回忆，并且人们倾向于把不确定的威胁情绪面孔判断为知道，即对于威胁“宁可错杀三千不可放过一个”。

3.2. 神经基础

目前针对威胁表情面孔记忆的研究普遍认为威胁表情有利于注意和知觉，从而产生记忆促进作用(Davis et al., 2011; Stiernströmer, Wolgast, & Johansson, 2016)。很多研究证实，威胁表情面孔具有与中性面孔不同的神经机制，会特异性激活与威胁注意偏向有关的杏仁核–前扣带回网络、脑岛等区域(Druzgal & Desposito, 2006；Fenker, Schott, Richardson-Klavehn, Heinze, & Duzel, 2005; Liu, Zhang, & Luo, 2014; Lo-Presti et al., 2008; Van den Stock, van de Riet, Righart, & de Gelder, 2008)，表明威胁情绪信息通过吸引注意，促进信息编码巩固达到记忆增强的效果(Ohman, Flykt, & Esteves, 2001)。进一步的研究发现，威胁面孔的再认过程会自动唤醒编码阶段的威胁情绪信息，从而在再认过程中引发左侧杏仁核和右侧眶额皮层(orbital frontal cortex，OFC)的更大激活(Satterthwaite et al., 2009)。

威胁情绪面孔的脑电研究给出了精细的时间加工证据，在早期注意分配相关的 N2pc 成分(Holmes, Bradley, Kragh Nielsen, & Mogg, 2009)，P1 成分和晚期 P300 成分(Lassalle & Itier, 2013; Liu et al., 2014)上的波幅优势表明，威胁表情通过注意捕获和注意维持增强威胁面孔的注意偏向。另有研究发现，倒置的威胁表情面孔相比于倒置的中性面孔会产生更小的 N170 波幅，以及与面孔表情相关的顶枕叶 P2 成分和额叶中部 N2 成分更小的波幅。威胁面孔倒置带来的影响更小，表明威胁表情面孔的编码优势可能依赖于局部的视觉结构(Ashley, Vuilleumier, & Swick, 2004; Stekelenburg & De, 2004)。

4. 威胁面孔记忆优势的产生原因

4.1. 进化优势假说

从进化心理学角度，能对威胁刺激进行意识下快速反应在自然环境中极占优势，而物种是否具备这种自适应功能会制约其进化与发展(Gernot, 2009)。这一假说认为进化的压力塑造了这种独特的视觉加工系统，从而能高效探测和加工威胁信息(Blanchard & Shiffrar, 2011)。具体而言，感觉信息的早期加工独立于当前的注意焦点，但及时探测威胁信号有利于生存，因此一旦发现威胁信息，系统就将注意指向威胁信息，这个过程又被称为自动威胁探测(Ohman & Mineka, 2001; Schmidt-D, 2011)。这意味着被视为短时记忆大门的注意会优先对威胁情绪信息敞开，使情绪信息得到更多的注意分配(Fox, Russo, Bowles, & Dutton, 2001; Hansen & Hansen, 1988)。大量研究证实了威胁面孔会产生选择性注意偏向(Feldmann-Wustefeld, Schmidt-Daffy, & Schubo, 2011; Fox & Damjanovic, 2006; Huang, Chang, & Chen, 2011)，造成注意脱离困难(Belopolsky, Devue, & Theeuwes, 2011; Horstmann & Bauland, 2006; Oaten, Stevenson & Case, 2009)。因此，进化优势假说认为，威胁面孔直接驱动的、自下而上的自动化注意捕获优势导致了威胁面孔的记忆优势，不过这种优势未区分威胁情绪和威胁身份。

4.2. 情绪唤醒假说

与 LeDoux (1996)的恐惧情绪唤醒的高低通路理论类似，Ohman 和 Mineka (2001)的恐惧刺激分析模型认为，恐惧刺激在初步特征加工后，会进入意义评估和唤醒系统；而恐惧刺激也可以跨过特征分析和

意义评估系统，粗略分析后直接进入唤醒系统，随后再把信息传至意义评估器，使加工过程更加迅速。可见威胁面孔可以迅速进入唤醒系统，提高个体唤醒水平，从而提升在任务过程中的努力程度和效率。威胁面孔的相关研究表明，具有威胁身份的面孔(如欺骗者)更值得被记住，并在编码阶段受到更久的注视，从而具有更好的再认成绩(Dan et al., 2004)。这反应了威胁面孔的编码优势源于对威胁情绪唤醒的评估，意义评估系统会因威胁信息的重要性而进行自上而下有意识的注意导向(Lagattuta & Kramer, 2017; Moriya, Koster, & De Raedt, 2014)。威胁面孔通过提高个体的唤醒水平提升加工效率，并自上而下将注意资源分配给威胁面孔，从而促进威胁面孔的记忆。这里突出了威胁的意义和重要性，但同样适用于威胁身份和威胁情绪面孔。

遗憾的是，目前的假说虽然出发点不尽相同，进化优势说是从注意捕获的角度，加工优势说主要从认知调控的角度，但这几种假设在一个实验中很难区分开，在威胁身份和情绪的实验中也同时存在。进一步精细的实验设计将有助于研究者在威胁面孔记忆的不同阶段验证两种假设的作用方式。

5. 小结与展望

以往研究证实，威胁面孔的记忆优势可能源自面孔身份和面孔表情两个方面。并且这种记忆优势可以从威胁面孔吸引注意、具有更高的知觉可辨性、重要意义等方面解释。未来研究还需要进一步考虑以下几个问题。

第一，从理论上，目前有关威胁面孔记忆的研究仍然没能很好地区分面孔情绪和面孔身份在记忆中的作用。对于威胁面孔而言，虽然已有研究证实威胁身份优先于表情加工(Vrtička et al., 2009)，但二者的相互关系和作用机制仍有待验证。面孔表情和面孔身份是互相独立的还是存在交互作用？Bruce & Young (1986)最先提出该问题，并认为面孔身份加工独立于面孔表情加工。但也有观点认为二者具有交互，稳定的身份信息存储在长时记忆中，而暂时性的表情信息同时与身份信息存储于短时记忆，从而为个体预测他人行为做准备(Jackson et al., 2009)。目前独立加工说和交互作用说争论不下。支持独立说的研究发现，面孔的身份可辨性不会影响面孔表情判断的速度，反之亦然(Caharel, Courtay, Bernard, Lalonde, & Rebaï, 2005)。面孔身份和表情加工的脑区也存在差异，面孔信息在经过初级视皮层之后，其中的身份信息会激活梭状回面孔区，而表情等动态信息则与颞上沟有关。此外临床人群中还发现了面孔失认症(Prosopagnosia)和卡普格拉错觉(Capgras delusion)患者在面孔情绪和身份上的双分离现象(Schweinberger & Burton, 2003)。然而也有研究支持交互说，面孔信息在经过初级视皮层加工后分为两部分，一部分动态信息(表情、角度)会直接传到颞上沟，另一部分信息(身份)的传递才与前人面孔知觉脑网络模型相符合；梭状回面孔区和颞下皮层也会受到表情的影响(Pitcher et al., 2014)，可见面孔表情的确对面孔身份的加工具有影响。

第二，目前研究主要关注威胁与非威胁面孔在记忆上的差异，缺乏对不同种类威胁面孔的对比。首先，大多研究证明了威胁面孔与非威胁面孔相比在记忆上的优势，然而研究所采用的威胁面孔各不相同，就威胁面孔表情而言，以愤怒面孔为主，恐惧、厌恶面孔皆有出现；就威胁面孔身份而言，以博弈中的欺骗、背叛者为主，包括厌恶、暴力行为者面孔，但是缺乏传染病等更多种类威胁身份面孔的研究。现有研究虽然各自发现威胁面孔的记忆优势效应，但其产生记忆优势的加工过程不尽相同，神经活动相应的也存在差异，可见仅比较威胁与非威胁面孔的差异，不足以认清威胁面孔记忆优势的机制。其次，虽然有个别研究对比不同种类威胁面孔在记忆上的差异，但多为两两比较，且只关注面孔记忆的某个阶段，这可能是造成目前不同威胁面孔行为或脑机制结果分散的原因之一。

第三，威胁面孔在记忆的不同阶段是否具备同样的优势？一方面，目前研究基本认可了威胁面孔在

记忆编码阶段的优势，而维持和提取阶段是否存在同样的记忆优势效应仍然存在争议。另一方面，研究发现即时威胁与潜在威胁在注意指向性上存在差异，但该差异是否会在面孔记忆的不同阶段发挥作用也有待进一步研究。

总之，未来研究要从面孔情绪和面孔身份着手，采用多种技术，进一步揭示威胁面孔记忆中二者的相互关系，以及在记忆不同阶段的作用机制。

基金项目

本项目得到中国科学院心理研究所基金(Y5CX122005)和北京市自然科学基金(5184035)资助。

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