Les événements émotionnels transitoires et les traits affectifs individuels affectent la reconnaissance des émotions dans une tâche de prise de décision perceptuelle

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Résumé

Les états affectifs ainsi que les traits de personnalité forgent la manière nous percevons le monde social et interprétons les émotions. Nombre de phénomènes psycho-pathologiques sont associés avec de tels biais ou distorsions. Dans la littérature, ces influences ont généralement été étudiées par des procédures d'amorçage affectif pour investiguer comment des stimuli émotionnels brefs affectent les traitements perceptuels et cognitifs. Pourtant, cette approche ne décrit pas complètement certains traitements plus dynamiques à la racine des interactions entre émotion et perception ou cognition, lorsque ces états émotionnels se prolongent au-delà de la durée des stimuli ou événements qui ont induits ces états.

Notre but était de mettre en perspective trois types différents d'états affectifs (états affectifs transitoires induits de façon externe et ceux plus prolongés d'origine interne, notamment l'état d'humeur et les traits de personnalité comme la dépression et l'anxiété), et d'investiguer comment ces processus interagissent et influencent la perception d'information émotionnelle. Notre hypothèse était que l'exposition à des épisodes émotionnels, positifs ou négatifs, génère des états affectifs prolongés, dépassant la durée de ces épisodes, susceptibles de modifier une tâche de décision perceptuelle, concernant l'interprétation d'expressions faciales.

Des états émotionnels transitoires ont été induits en utilisant des clips vidéos. Après cela, les participants ont effectué une tâche de choix forcé (classification des émotions) pour des images de visages exprimant un gradient d'émotions faciales (morphes), s'étendant de la peur à la joie. En utilisant une approche psychométrique, nous avons observé que les clips vidéos négatifs (vs. neutres) augmentaient la tendance à classer les visages ambigus (expressions intermédiaires

entre peur et joie) comme effrayés, pendant plusieurs minutes. Par contre, les films positifs biaisaient cette classification vers la joie. L'humeur négative de base de l'individu, l'anxiété et la dépression, augmentaient également la tendance à classifier des visages ambigus comme effrayés, avec un effet plus fort que les états transitoires induits. Nos résultats démontrent pour la première fois que l'absorption par différentes émotions et leurs dimensions temporelles produisent des effets significatifs et soutenus (pendant plusieurs minutes) sur la manière dont nous percevons les expressions d'émotions dans le visage d'autrui. Cette méthode de mesure des biais d'interprétation des expressions faciales pourrait constituer une méthode simple pour dépister objectivement et précocement des états affectifs négatifs persistants, et/ou évaluer quantitativement l'efficacité de thérapies visant à modifier ces états thymiques. Renforcer des émotions positives au moyen de vidéos dont le contenu ou l'absorption seraient personnalisés pour chaque patient, avec son consentement éclairé, offre ainsi une perspective originale afin de prévenir et traiter symptomatiquement des biais négatifs susceptibles de renforcer l'isolement social dont souffrent souvent les patients anxieux et déprimés.

Introduction

Influence des émotions positives sur les interactions sociales

Le bonheur est fortement influencé par la qualité des interactions sociales. Il est donc primordial de mieux comprendre les facteurs susceptibles d'affecter la qualité des relations sociales (Lopes, Salovey, Côté, & Beers, 2005). En outre, les interactions de meilleure qualité sont associées à de meilleures capacités à réguler ses émotions. En particulier, les émotions positives conduisent à un plus bas niveau de stress et de dépression (Wood, Maltby, Gillett, Linley, & Joseph, 2008). Elles sont aussi associées à de meilleures compétences sociales et au succès (Fredrickson & Losada, 2005; Lyubomirsky, King, & Diener, 2005).

Le but de cette étude comportementale est d'investiguer comment les émotions modulent le traitement des informations sociales, notamment celles associées aux visages. Une information sociale majeur est en effet l'expression faciale (Darwin, 1872). Nous avons cherché à déterminer si les états émotionnels, transitoires induits ou persistants préalables, peuvent biaiser notre interprétation des expressions émotionnelles exprimées dans le visage d'autrui. En d'autres termes, les lunettes roses du bonheur font-elles interpréter des visages neutres comme plus joyeux ? Et les lunettes grises du malheur font-elles interpréter des visages neutres comme plus négatifs ? De tels effets peuvent avoir un impact important sur la vie sociale quotidienne, comme il est plus gratifiant et plus facile d'interagir avec des interlocuteurs souriants ; mais ils peuvent également apporter des informations nouvelles pour la compréhension et l'évaluation de troubles psychopathologiques associés à des biais perceptifs ou cognitifs d'origine affective.

Impact des émotions sur la cognition

Les émotions ont un impact sur bon nombre de fonctions cognitives (Brosch, Scherer, Grandjean, & Sander, 2013). Par exemple, les stimuli émotionnels sont mieux mémorisées (Hamann, 2001; Phelps, 2004; Sharot, Delgado, & Phelps, 2004), en particulier s'ils sont congruents à l'humeur (Fitzgerald et al., 2011). Ils attirent l'attention comme dans le cas des stimuli dangereux qui doivent être traités rapidement pour survivre (Ohman, Flykt, & Esteves, 2001; Phelps, Ling, & Carrasco, 2006; Vuilleumier, 2005). Les émotions modulent ainsi l'attention au niveau visuel et sémantique (Rowe, Hirsh, & Anderson, 2007; Schmitz, De Rosa, & Anderson, 2009). Elles influencent la prise de décision (Andrade & Ariely, 2009; Cassotti et al., 2012; Coricelli et al., 2005; Harlé, Chang, van 't Wout, & Sanfey, 2012; Knutson, Wimmer, Kuhnen, & Winkielman, 2008; Loewenstein, Weber, Hsee, & Welch, 2001) et les décisions morales (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). Elles moduleraient aussi l'accès aux représentations d'autrui. En effet, les émotions positives faciliteraient l'accès à la perception de la douleur d'autrui et à la déduction des émotions d'autrui à partir de situations (Qiao-Tasserit, Corradi-Dell'Acqua, & Vuilleumier, 2017, Qiao-Tasserit et al., in prep.). Cependant l'impact des émotions sur la perception des visages n'est pas clair.

Méthodes d'induction émotionnelle

Pour étudier les émotions, les chercheurs ont souvent recours à des techniques d'induction émotionnelle telles que la présentation d'images émotionnelles, de textes, de vidéos, d'odeurs, de musique ou de souvenirs autobiographiques (Gaillard et al., 2006; Jallais & Gilet, 2010; Jiang,

Scolaro, Bailey, & Chen, 2011; Qiao-Tasserit et al., 2017; Sereno, Scott, Yao, Thaden, & O'Donnell, 2015; Sharvit, Vuilleumier, Delplanque, & Corradi-Dell'Acqua, 2015; Zelman, Howland, Nichols, & Cleeland, 1991). Une étude a montré que les vidéos sont plus efficaces que la musique pour induire des états émotionnels (Lazar & Pearlman-Avnion, 2014). Nous utilisons dans cette étude des vidéos positives, neutres et négatives qui ont été utilisées dans d'autres publications du laboratoire (Eryilmaz, Van De Ville, Schwartz, & Vuilleumier, 2011; Pichon, Miendlarzewska, Eryilmaz, & Vuilleumier, 2014; Pichon, Rieger, & Vuilleumier, 2012, Qiao-Tasserit et al., in prep.). L'efficacité de ces vidéos pour induire un état émotionnel transitoire a été étudié notamment avec l'imagerie cérébrale. En effet, après la visualisation de ces vidéos positives et négatives, la connectivité cérébrale est modifiée au repos pendant au moins 90 secondes. Elle est augmentée entre deux régions cérébrales responsables notamment du traitement des informations intéroceptives et des représentations affectives, l'insula et le cortex cingulaire antérieur (Eryilmaz et al., 2011). Les vidéos négatives augmentent l'activation d'une région décrite classiquement comme réactive à la menace, l'amygdale, tandis que les vidéos positives diminuent cette activation (Pichon, Miendlarzewska, Eryilmaz, & Vuilleumier, 2014b).

Perception des visages

La perception des expressions faciales influe sur le comportement. Par exemple, les personnes qui reconnaissent bien la peur sur les visages adoptent un comportement plus prosocial (Marsh, Abigail & Ambady, 2007; Marsh, Kozak, & Ambady, 2007). De manière intéressante, le contexte

émotionnel pourrait moduler la perception des émotions sur le visage (Mobbs et al., 2006; Wieser & Brosch, 2012).

Importance clinique de l'étude

Les pathologies liées à la régulation des émotions et du stress sont un problème majeur de santé publique. Près de 10% de la population mondiale est touché par la dépression et/ou l'anxiété (Organisation Mondiale de la Santé, 2017). En 2010, la prévalence de la dépression était de 3.2% pour les hommes et de 5.5% pour les femmes, et celle de l'anxiété était de 7.3%. Le coût des traitements liés à la dépression et à l'anxiété entre 2016 et 2030 est estimé à 147 milliards de dollars pour 36 pays regroupant environ 80% de la population mondiale (Chisholm et al., 2016). Sans ces traitements, le coût de la perte de productivité se chiffrerait à 925 milliards de dollars pour ces pays, soit plus de 50 millions d'années de travail.

Les troubles émotionnels peuvent en effet être associés à un déficit non seulement au niveau affectif mais aussi au niveau motivationnel et cognitif (Austin, Mitchell, & Goodwin, 2001). De tels déficits peuvent se traduire par la présence de biais d'interprétation négatifs des informations sociales, favorisant l'isolement social. L'isolement social et la solitude sont associés à une plus grande mortalité (Steptoe, Shankar, Demakakos, & Wardle, 2013). L'isolement social contribuerait à une baisse des performances, un déclin cognitif et un biais social négatif poussant à un repli sur soi (Cacioppo & Hawkley, 2009).

Il est donc important de dépister précocement les biais de négativité liés au traitement des informations sociales pour prévenir le cercle vicieux entre déficits cognitifs et isolement social.

L'apparition d'un biais d'interprétation de l'expression des visages pourrait constituer un marqueur de mesure simple de troubles de la régulation des émotions. En effet, les patients souffrant de tels troubles seraient plus sujets à interpréter les expressions faciales négativement.

Par exemple, les patients dépressifs et vulnérables à la dépression ont tendance à interpréter et mémoriser les visages neutres comme négatifs (Bistricky, Ingram, & Atchley, 2011). De plus, leur attention serait attirée par les visages négatifs et ces patients seraient moins sensibles aux expressions faciales positives (Surguladze et al., 2004; Yoon, Joormann, & Gotlib, 2009). Ces facteurs contribuent à percevoir négativement les relations sociales et à se replier socialement.

Les données concernant les patients souffrant de troubles bipolaires sont moins claires. Certaines études montrent un biais d'interprétation congruent avec l'humeur en phase dépressive, et d'autres études sont mitigées (Gray et al., 2006; Venn et al., 2004). Cependant, les patients avec bipolarité présentent une réponse cérébrale aux visages positifs et négatifs accrue par rapport aux patients sains ou avec dépression, dans des régions sous corticale et du cortex ventral préfrontal (Lawrence et al., 2004). Cette hyperactivité suggère que les stimuli positifs et négatifs sont plus saillants chez ces patients, contribuant certainement à l'augmentation de leur labilité émotionnelle. Les patients souffrant de troubles de l'humeur souffrent souvent aussi d'anxiété.

Les patients souffrant d'anxiété sont attirés par les stimuli négatifs menaçants (Mathews, Mackintosh, & Fulcher, 1997). Au niveau neural, les personnes qui ont un score élevé d'état anxieux réagissent plus fortement aux vidéos émotionnelles utilisées dans cette étude. Ils présentent une modulation de l'amygdale plus importante, témoin de leur vulnérabilité au stress (Pichon et al., 2014).

Dans notre expérience, nous avons étudié si une tendance persistante à la négativité chez nos sujets sains peut biaiser l'interprétation des expressions faciales. Les participants ont rempli des questionnaires d'humeur, de dépression et d'anxiété et leurs réponses ont été corrélées à leur réponses à la tâche principale de classification des expressions faciales.

But de la recherche

Le but de cette étude est de déterminer comment les émotions, transitoires et/ou persistantes, influencent la perception des émotions d'autrui. Pour mesurer l'influence des états émotionnels *transitoires*, nous avons induit des émotions à l'aide de vidéos positives, neutres et négatives. Après avoir visionné chaque vidéo, les participants ont vu des morphes de visages qui montraient un éventail d'expressions entre la joie et la peur (Fig 1.A). Les participants devaient classifier l'expression vue sur les visages comme joyeuse ou effrayée. Pour mesurer l'influence de l'humeur et des traits de personnalité, nous avons également administré des questionnaires et corrélé les résultats avec ceux de la tâche de classification des expressions faciales.

Fig 1.A) Exemple de continuum de morphes s'étendant entre la peur et la joie

100 % peur — 15 niveaux de morphes et 18 identités — 100 % joie

Notre hypothèse est qu'il est possible d'induire un biais d'interprétation des expressions faciales ambiguës suite à la présentation de vidéos à fort contenu émotionnel. De plus, ce biais devrait être congruent avec l'émotion induite. En d'autres termes, davantage de visages ambigus seraient classifiés comme joyeux après des vidéos positives et comme effrayés après des vidéos négatives. En outre, les participants d'humeur négative, et/ou avec des traits de personnalité anxieux ou dépressifs présenteraient un biais d'interprétation négatif des visages.

Article original, attaché en annexe

Titre

Transient emotional events and individual affective traits affect emotion recognition in a perceptual decision-making task.

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Discussion

Dans cet article, nous avons testé si les émotions pouvaient affecter l'interprétation des expressions faciales. Les participants ont présenté un biais d'interprétation négatif après induction émotionnelle par les vidéos négatives. Ils ont classifié davantage d'expressions faciales ambiguës comme effrayées après une vidéo négative. A l'inverse, après les vidéos positives, ils ont également présenté un biais d'interprétation positif mais uniquement après les vidéos qu'ils ont notées comme très absorbantes. En effet, contrairement aux contenus de dangers dans les vidéos négatives qui sont universels, l'humour diffère selon les individus et les normes culturelles. Cette étude souligne l'importance d'évaluer l'efficacité des inductions émotionnelles positives dans les études utilisant l'induction émotionnelle, par exemple via l'absorption. Les participants avec des émotions négatives persistantes, d'humeur négative, avec des traits anxieux ou dépressifs, présentent aussi un biais d'interprétation des expressions faciales négatif. Ce biais négatif lié aux émotions négatives persistantes était plus fort que celui lié aux émotions négatives transitoires et il n'y avait pas d'interaction significative.

Ces résultats sont en accord avec la théorie de l'incarnation *(embodiement theory)* qui postule que nous utilisons des informations de notre propre corps pour traiter des informations d'autres individus (Halberstadt, Winkielman, Niedenthal, & Dalle, 2009; Niedenthal, Barsalou, Winkielman, Krauth-gruber, & Ric, 2005). Ils vont aussi dans le même sens que la théorie du biais d'égocentricité *(emotional egocentricity bias)* qui suppose une tendance à projeter son propre état mental sur celui des autres (Silani, Lamm, Ruff, & Singer, 2013). Ils convergent également avec la théorie de la congruence entre l'humeur et les stimuli *(mood congruency hypothesis)* qui

postule qu'une humeur positive favorise l'attention vers des stimuli positifs tandis qu'une humeur négative vers des stimuli négatifs (Becker & Leinenger, 2011; Watkins, Vache, Verney, Muller, & Mathews, 1996). D'ailleurs, les biais attentionnels positifs pourraient promouvoir le bien-être et calmer la dépression (Xu et al., 2015).

Une autre théorie *(Broaden-and-build theory)* décrit que les émotions positives favorisent un élargissement du scope attentionnel et permettent d'accroître les ressources cognitives pour s'épanouir (Fredrickson, 2004). Mais cette théorie est remise en cause pas des résultats hétérogènes. Une explication pourrait résider dans le fait que les émotions positives ne moduleraient pas le focus attentionnel per se. Elles moduleraient la capacité de porter son attention sur les stimuli externes *(top-down attention)* de manière non sélective et large, ainsi que la capacité d'avoir l'attention détournée par des stimuli externes *(bottom-up attention).* Cette modulation dépendrait du degré contrôle cognitif requis par la tâche à effectuer. Si la tâche à effectuer est compliquée et demande donc plus de contrôle cognitif, l'attention est davantage focalisée sur les stimuli externes pertinents pour la tâche. Or le degré de contrôle cognitif dépend du type et de la difficulté de la tâche à effectuer et les tâches sont différentes d'une étude à l'autre. Ces différences de degré de contrôle cognitif pourraient expliquer les différences d'effet des émotions positives sur l'élargissement du scope attentionnel entre les études (Vanlessen, De Raedt, Koster, & Pourtois, 2016).

Au niveau neural, ces biais d'interprétation seraient modulés par plusieurs régions cérébrales. Dans une étude IRM conduite dans notre laboratoire, les chercheurs ont examiné l'activité cérébrale des participants pendant la période de repos après avoir regardé les mêmes clips vidéos que ceux utilisés dans notre étude. Le couplage des activités du cortex cingulaire antérieur

et de l'insula était augmenté, reflétant certainement l'intégration et la régulation d'information intéroceptives ainsi que la représentation de l'état affectif et motivationnel. Le couplage de l'activité du cortex préfrontal ventro-médial et de l'amygdale était diminué, suggérant une concentration des pensées sur le contenu émotionnel des films. De plus, le lobule pariétal inférieur présentait une connectivité augmentée avec l'insula et le cortex cingulaire antérieur, ce qui évoque que l'attention est portée sur les informations affectives et intéroceptives (Eryilmaz et al., 2011). Une autre étude du laboratoire utilisant aussi les même clips vidéos montre que l'amygdale pourrait aussi jouer un rôle important (Pichon et al., 2014). Son activité était atténuée par les clips positifs, ce qui permettrait d'augmenter la résilience contre les stimuli effrayants. A l'inverse, son activité était augmentée par les clips négatifs, ce qui permettrait de s'attarder sur des informations négatives de danger. Il est intéressant de noter que dans cette étude, l'amplitude de cette modulation de l'activité de l'amygdale augmentait avec les scores d'anxiété subclinique des participants sains. Cette plus forte modulation de l'amygdale chez les individus plus anxieux suggère qu'ils présentent une plus forte inertie émotionnelle.

L'interprétation d'une expression faciale, un signal majeur de communication sociale, ne serait pas universelle, mais dépendrait aussi de notre culture (Jack, Garrod, Yu, Caldara, & Schyns, 2012), de notre état émotionnel de l'instant, de nos traits de personnalité (Qiao-Tasserit et al., 2017). Une seule minute de film a suffi dans notre étude pour induire un biais mesurable. Par ailleurs, des chercheurs ont comparé des personnes qui consomment peu de medias violents à des personnes qui en consomment beaucoup. Ces derniers seraint plus rapides à reconnaître la colère sur les visages et plus lent à reconnaître la joie, et cela indépendamment de leur trait de personnalité aggressive (Kirsh, Mounts, & Olczak, 2006).

Les biais d'interprétation des expressions du visage ne seraient pas spécifiques à la joie ou à la peur. Une autre étude romande suggère qu'une induction émotionnelle triste biaise la reconnaissance des visage vers la tristesse (Schmid & Schmid Mast, 2010). Mais la tristesse pourrait biaiser la perception de manière différente de la peur. Les personnes tristes auraient une meilleure reconnaissance des émotions faciales (Hills, Werno, & Lewis, 2011) et ne présenteraient pas les mêmes biais attentionnels négatifs que les patients anxieux (Lichtenstein-Vidne et al., 2017).

Un défi est de prévenir l'aggravation d'un mal-être dépressif par un cecle vicieux pouvant entretenir des ruminations négatives. Les émotions négatives ont en effet le pouvoir de rendre la perception du monde plus négative, au niveau du toucher en augmentant la réponse cérébrale à la douleur physique au niveau de l'insula postérieure (Qiao-Tasserit et al., 2018; Villemure & Bushnell, 2009), au niveau de la vue en percevant des visages neutres comme plus négatifs (Qiao-Tasserit et al., 2017). De plus, elles peuvent biaiser des processus plus complexes au cœur des relations humaines comme l'empathie, en réduisant les activités cérébrales de l'empathie pour la douleur au niveau de l'insula antérieure et du cortex cingulaire moyen (Qiao-Tasserit et al., 2018), ou perturber la capacité de déduire qu'une autre personne est joyeuse du fait qu'elle se trouve dans une situation joyeuse, en réduisant les activités cérébrales liées à l'inférence des émotions positives chez autrui (Qiao-Tasserit et al., in prep.).

Un événement stressant peut aussi entraîner un état négatif et reduire les capacités de régulation des émotions (Raio, Orederu, Palazzolo, Shurick, & Phelps, 2013). Le stress altèrerait notamment le contrôle cognitif de la peur. Des chercheurs ont récemment tenté de prévenir un tel état négatif en situation de stress avec une induction émotionnelle positive juste après un événement

négatif (Speer & Delgado, 2017; Yang et al., 2018). Se rappeler de bons souvenirs permettrait de réduire les émotions négatives ainsi que d'atténuer les effets physiologiques du stress, notamment chez les participants qui présentent une résilience importante, via le cortex préfrontal latéral (Speer & Delgado, 2017). La partie médiale du cortex préfrontal pourrait aussi jouer un rôle pour se décentrer de ses propres émotions négatives (Yang et al., 2018).

L'induction d'émotions positives pourrait donc offrir également une alternative intéressante par rapport aux stratégies de réinterprétation des événements négatifs (Gross, 2002) qui peuvent être inefficaces en cas de stress (Raio et al., 2013). D'ailleurs, pour combattre l'anxiété, les tâches visant modifier les biais attentionnels qui valorisent la recherche active d'informations positives en utilisant des processus de contrôle cognitifs variés, seraient plus efficaces que celles qui tentent d'éviter les informations négatives (Mogg & Bradley, 2016). Avantageusement, les méthodes d'induction émotionnelle positive, comme regarder une minute de film positif dans le cadre de notre étude, sont relativement simples à mettre en œuvre et pourraient être utiles en clinique comme moyen additionnel aux approches actuelles centrées sur les traitements pharmacologiques et la psychothérapie.

Implications cliniques

L'induction émotionnelle constitue un modèle intéressant pour étudier chez des volontaires sains l'effet d'émotions liées à des pathologies psychiatriques, comme la tristesse dans la dépression ou le stress dans l'anxiété. Les volontaires sains sont souvent en pratique plus faciles à recruter

et ont plus de facilité à exécuter les instructions que les patients. Cela dit, une prochaine étude pourrait utiliser le même paradigme avec des patients.

Chez les patients psychiatriques, cette procédure mesurant les biais négatifs pourrait permettre de dépister simplement des troubles de la régulation émotionnelle. De plus, les procédures d'induction des émotions constituent une approche non invasive intéressante pour biaiser positivement l'interprétation des signaux sociaux. Des chercheurs ont utilisé des histoires pour créer un biais d'interprétation positive avec succès chez les patients souffrant d'anxiété (MacLeod & Mathews, 2012; Salemink, van den Hout, & Kindt, 2009, 2010). Chez les patients souffrant de dépression, les résultats des études utilisant des procédures de modification des biais semblent moins claires (Hallion & Ruscio, 2011) et seraient efficaces seulement si les symptômes sont légers (Baert, De Raedt, Schacht, & Koster, 2010). Cependant, chez les patients en rémission de dépression, des procédures permettant d'induire un biais attentionnel vers des visages positifs sembleraient être efficaces pour réduire le risque de rechute (Browning, Holmes, Charles, Cowen, & Harmer, 2012).

En particulier, la mesure du biais d'interprétation des visages induite par les vidéos pourrait constituer une méthode simple de dépistage et d'évaluation quantitative de l'efficacité des thérapies des troubles de la régulation des émotions. Il est en effet difficile de quantifier un tel biais par soi-même ou par un questionnaire subjectif, d'où l'intérêt de notre procédure, qui serait réalisée dans le respect du consentement éclairé du patient. A l'ère de la médecine personnalisée, l'induction émotionnelle positive devrait être adaptée à chaque individu pour augmenter son efficacité, notamment en calibrant l'absorption des vidéos positives, leur contenu et leur durée.

Les thérapies cognitives visant l'induction de biais positifs pourraient s'inscrire en complément d'autres procédures, psychodynamiques ou pharmacologiques. Par exemple, l'ocytocine permettrait d'améliorer la recognition des expressions faciales joyeuses spécifiquement, et non de colère, dégoût, peur, tristesse ou surprise (Marsh, Yu, Pine, & Blair, 2010).

Du côté des soignants, l'empathie diminue au cours des études médicales notamment lorsque les étudiants commencent à être en clinique au contact des patients (D. C. R. Chen, Kirshenbaum, Yan, Kirshenbaum, & Aseltine, 2012; D. Chen, Lew, Hershman, & Orlander, 2007). Or les personnes avec moins d'empathie seraient moins sensibles aux expressions faciales comme la colère ou la joie (Dimberg, Andréasson, & Thunberg, 2011). Il serait intéressant de réaliser cette étude chez les soignants, pour voir s'ils sont en effet moins sensibles aux expressions faciales et dans quelle mesure cette sensibilité pourrait être modulée par leurs émotions. Par ailleurs, le fait même de prendre conscience que les émotions induites par seulement une minute de film émotionnel peuvent affecter l'interprétation de l'expression des visages et aussi de l'empathie à la douleur peut avoir un impact sur la relation thérapeutique et la prise en charge des patients (Qiao-Tasserit, Corradi-Dell'Acqua, & Vuilleumier, 2017). Cette étude montre qu'une minute de film positif suffit pour diminuer la réponse cérébrale à sa propre douleur au niveau de l'insula postérieure, alors qu'une minute de film négatif suffit pour diminuer celle liée à la douleur d'autrui au niveau des aires cérébrales liées à l'empathie pour la douleur, l'insula antérieur et le cortex cingulaire moyen.

Plusieurs méthodes augmentent avec succès l'empathie chez les soignants et ont un effet favorable dans la relation avec le patient (Bonvicini et al., 2009; Jenkins & Fallowfield, 2002; Krasner, 2009; Larson, 2005; Poole & Sanson-Fisher, 1980). En particulier, combiner plusieurs méthodes comme prendre conscience de la physiologie des émotions et améliorer le décodage des expressions faciales subtiles des émotions, permettrait aux soignants d'améliorer leurs capacités d'empathie et ainsi d'être perçus comme plus empathiques par les patients.

Dans une étude américaine, les chercheurs ont assigné aléatoirement 99 internes de différentes spécialités à deux groupes (Riess, Kelley, Bailey, Dunn, & Phillips, 2012). Un groupe a suivi une formation post-graduée standard et l'autre groupe une formation post-graduée augmentée d'un entraînement à l'empathie d'une heure pendant 4 semaines. L'entraînement à l'empathie avait pour principe d'apprendre à décoder les expressions faciales subtiles, de comprendre les bases scientifiques de cet entrainement, de prendre conscience des émotions dans la relation avec le patient et à répondre de manière empathique. Par la suite, les patients ont attribué un score d'empathie plus élevé aux médecins qui avaient reçu l'entraînement à l'empathie. De plus, ces médecins présentaient une meilleure aptitude à décoder les expressions faciales et ont rapporté une meilleure connaissance de la neurobiologie de l'empathie. De manière intéressante, les chercheurs ont noté une forte corrélation entre l'amélioration de la capacité à reconnaitre des expressions faciales subtiles et les scores d'empathie attribués par les patients.

Notre étude montre que cette capacité à reconnaitre des expressions faciales est modulée par les émotions. D'autres recherches sont bien sûr nécessaires pour connaître l'impact d'un tel savoir sur l'empathie et la relation avec les patients. Car l'empathie du soignant perçue par les

patients est un facteur clé de l'adhérence aux traitements et d'un meilleur résultat de la prise en charge (Squier, 1990).

Conclusion

Nous avons montré que les états affectifs transitoires induits par des stimuli externes, comme une minute de film émotionnel, ont la capacité de biaiser la manière dont nous percevons les expressions faciales. De manière plus importante que les états affectifs transitoires, les états affectifs prolongés, liés à une humeur négative et/ou à des traits dépressifs et anxieux, biaisent également la perception de visages neutres qui sont plus volontiers classés comme négatifs. Ce biais est difficile à mesurer soi-même ou à quantifier par un entretien clinique, d'où l'intérêt potentiel de procédures similaires à la nôtre, pour dépister précocement des états affectifs négatifs persistants. Percevoir à tort des visages neutres comme étant négatifs et hostiles pourrait non seulement renforcer un affectif négatif, mais aussi favoriser un repli sur soi et l'isolement social, dont souffrent souvent les patients atteints de maladies psychiatriques. De manière intéressante, notre étude suggère qu'une induction émotionnelle positive personnalisée pour chaque patient pourrait offrir un espoir de prévenir et traiter symptomatique ce biais, ceci dans la mesure où il serait effectué dans le respect du consentement éclairé du patient, et peut-être combiné à d'autres interventions déjà courantes, psychothérapeutiques ou pharmacologiques.

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RESEARCH ARTICLE

Transient emotional events and individual affective traits affect emotion recognition in a perceptual decision-making task

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Abstract

Both affective states and personality traits shape how we perceive the social world and interpret emotions. The literature on affective priming has mostly focused on brief influences of emotional stimuli and emotional states on perceptual and cognitive processes. Yet this approach does not fully capture more dynamic processes at the root of emotional states, with such states lingering beyond the duration of the inducing external stimuli. Our goal was to put in perspective three different types of affective states (induced affective states, more sustained mood states and affective traits such as depression and anxiety) and investigate how they may interact and influence emotion perception. Here, we hypothesized that absorption into positive and negative emotional episodes generate sustained affective states that outlast the episode period and bias the interpretation of facial expressions in a perceptual decision-making task. We also investigated how such effects are influenced by more sustained mood states and by individual affect traits (depression and anxiety) and whether they interact. Transient emotional states were induced using movie-clips, after which participants performed a forced-choice emotion classification task with morphed facial expressions ranging from fear to happiness. Using a psychometric approach, we show that negative (vs. neutral) clips increased participants' propensity to classify ambiguous faces as fearful during several minutes. In contrast, positive movies biased classification toward happiness only for those clips perceived as most absorbing. Negative mood, anxiety and depression had a stronger effect than transient states and increased the propensity to classify ambiguous faces as fearful. These results provide the first evidence that absorption and different temporal dimensions of emotions have a significant effect on how we perceive facial expressions.

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Introduction

Emotions and mood provide powerful prisms which shape the way individuals interpret social information and their environment. Depending on their affective state, people may see the glass as either half full or half empty when evaluating the same situation. But although these statements seem well known and almost trivial, little research has been conducted to characterize the impact and temporal aspects of such phenomena and to systematically compare the influence of negative and positive affective states on perception. Moreover, most priming studies assume that these biases are short-lived and do not persist more than a fraction of second. Here we addressed this issue by using a simple forced-choice categorization task where subjects evaluated facial expressions morphed between fear and happiness after being exposed for several minutes to negative, positive, or neutral movie clips. Our aim was to measure bias in expression categorization induced by transient affective states and estimate whether such bias persists during the entire duration of the categorization task. We also tested whether such biases depend on more persistent affective states related to individual personality characteristics such as positive and negative mood as well as sub-clinical levels of anxiety and depression.

Unlike persistent affective states such as mood, emotions are generally conceived as short-lived events of physiological, motivational, and psychological changes that have a definite cause, a distinctive cognitive and experiential content, and a rapid decay after elicitation [1,2]. Some studies using EEG have characterized the temporal unfolding of brain responses to emotional events (pictures) and pointed to differential dynamics at the timescale of the second for different emotions [3,4]. However, little is known about changes in behavior and brain activity occurring over several seconds or minutes after emotional events [5]. Likewise, the literature on affective priming has mostly focused on very brief influences of emotional stimuli on perceptual and cognitive processes by employing cue-target paradigms similar to the ones used in the spatial or psycholinguistic domains. In this framework, affective priming typically designates the effect produced by a brief emotional stimulus (the prime) on the evaluation of subsequent information (the target) [6,7]. Affective priming has also been investigated using subliminal masked priming [8,9]. Such affective priming effects are inherently short-lived and dissipate after a fraction of a second [10–12].

However, little has been documented on situations where emotional information is presented for longer periods of time, such as when subjects watch a movie, listen to music, or imagine an emotional event before evaluating a target. Such situations may 'infuse' affective states and impact cognitive states over longer periods of time, as proposed in the affect infusion model [13]. The affect infusion model has specifically considered that such extended affective states can modulate the encoding, retrieval, and selective use of information. Such extended states can influence the interpretation of subsequent events even after transient emotions have 'faded away' and their experiential content has vanished [14–16]. For instance, watching a movie depicting either a funeral or a child playing, will imbue a subsequent neutral scene with either negative or positive meaning [17,18]. This phenomenon, referred to as the Kuleshov effect used in film editing, can also operate on the perception of neutral faces, and it implies some transfer of emotional or mental content between one movie scene and the perceived facial expression of a character in the next scene [17]. However, few empirical studies have directly investigated the influence of affective states on face perception [5,17–19]. To our knowledge, no study has investigated whether a transient emotion induction procedure can induce interpretation biases for facial expressions, whether the induced biases quickly vanish after induction or persist over several minutes, and whether such interpretation biases vary according to the valence of emotional state. These questions constituted the first objective of the current study.

In a related but different literature, persistent negative emotional states associated with low mood, depression, or anxiety, have frequently been shown to yield a negative interpretation bias. These traits tend to favor negative over positive interpretations [20–22] of ambiguous positive-negative faces [23–26] or ambiguous semantic information [27]. A negative interpretation bias is a type of cognitive bias where there is a tendency to interpret ambiguous stimuli in a negative manner when others would favor positive interpretations [20,21]. According to cognitive theories of depression and anxiety, negative cognitive biases have a major, perhaps causal role in the development and maintenance of depressive and anxious states [28].

Therefore, the second objective of our study was to measure subject-wise interpretation biases for facial expressions induced by emotional states in relation to individual differences in mood, anxiety, and depression indices. Indeed, persistent negative states, such as depression, are associated with anhedonia and various emotional biases in perception and attention [29,30]. Given that emotional blunting is frequent in depressed patients, whereas heighted emotional reactivity is commonly associated with anxiety [31], we expected a decreased or exaggerated emotion induction effect in subjects with higher depression or higher anxiety scores, respectively.

Finally, another important factor likely to influence the impact of emotional signals on cognition and perception is the degree of absorption while individuals process emotional information. Yet, to our knowledge, the effect of absorption has been little characterized experimentally. With respect to affects, absorption refers to the extent to which individuals allow themselves to be drawn into an emotional experience. Tellegen and Atkinson (1974) defined absorption as a state of "total attention, involving a full commitment of available perceptual, motoric, imaginative and ideational resources" [32]. Recent evidence indicates that trait absorption is related to enhanced emotional picture processing [33]. Thus, a high absorption state during the processing of emotional information may potentiate more vigorously subsequent interpretation biases than a low absorption state.

Accordingly, several recent studies using neuroimaging techniques have shown that exposure to emotional stimuli using movies [5,34,35] or other emotion-inducing procedures [36] can produce lasting changes in patterns of brain activity, both during resting state [34] and during unrelated perceptual or semantic tasks [19,35,36]. In one study using faces [5], amygdala response to fearful facial expressions (compared to neutral) was enhanced for several minutes following exposure to fear-inducing movies, but attenuated following joyful movies. Furthermore, this study found that such effects were stronger for highly absorbing emotional movies [5]. It remains unknown, however, whether these neural changes are mirrored by measurable behavioural changes in facial expression recognition.

Hence, the goal of the present work was to investigate how transient positive and negative emotions induced by movie-clips influence emotion discrimination for negative and positive facial expressions, using morphed stimuli ranging from pure fear to pure happiness. We also tested how individual characteristics related to persistent mood, personality traits, and experiential absorption would modulate such influences. We predicted that negative and positive emotional states, both transient and persistent, should result in state-congruent interpretation biases for ambiguous facial expressions along the negative-positive continuum.

Methods

Subjects

45 healthy right-handed volunteers participated in this study (22 females, mean age±std 24.1 ±3.5, range = 18–32). One participant gave random responses was excluded for failing to comply with the instructions. All participants gave their informed written consent before

participating in the study, which was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The study protocol, inclusion criteria, and consent procedure were reviewed and approved by the ethical committee of the University of Geneva. Participants were compensated for their participation in this study. None had a history of psychiatric or neurological disease, and none took drugs or medication at the time of testing.

Procedure

During the experiment, participants performed two intermixed tasks arranged in 18 short sessions, all given in a single day and separated by brief rest breaks. At the beginning of each session, subjects watched a positive, negative, or neutral movie clip (~ 50sec–1 min) that was immediately followed by a decision-making task on a series of 15 faces (~2mn). Each face was presented during 500ms and preceded by a fixation cross (500ms). They had to indicate if the face expressed fear or happiness (2 alternatives forced-choice task, Fig 1) without imposed response time limit. Facial expressions were morphed from fear to happiness (see below). To keep the goal of the experiment implicit, participants were told that they would participate in two different studies performed in alternating sessions, to make the experiment less repetitive. The objective of the first study would be to measure their emotional reaction to short negative/threatening, positive/joyful, or neutral film excerpts via their skin conductance response. Participants were instructed to get immersed in the movies as much as possible without being critical. They were told that the objective of the second study would be to measure their ability to recognize fear and happiness in ambiguous morphed faces.

Movie stimuli

We used 6 movie clips per emotion conditions (negative, positive, and neutral). Movies were selected from a standard database of emotional movies [37]. Each session comprised one movie excerpt followed by 45 facial morphs. Previous studies using the same movies confirmed reliable difference in their valence [34], and showed sustained changes in brain activity and peripheral autonomic state (skin conductance and pupil size) induced by both negative and positive emotional movies (relative to neutral ones), extending for several minutes after the movies [5]. Examples of movies included *The Shining* (negative), *When Harry met Sally* (positive), or documentaries such as *Cosmos Mysteries* (neutral); see full list in [34]. We equated luminance across movies. Mood's median tests confirmed that audiovisual features were matched across contexts [luminance ($p = .13$), motion ($p = .69$), spatial frequency ($p = 1$), acoustic intensity and power ($p > .51$)]. To potentiate mood induction, movies from the same valence were grouped in successive sessions intermixed with the decision-making task, but the order of movies within emotional contexts was randomized between subjects. Half of the participants saw negative movies first, followed by neutral and positive movies. Another half of participants performed the task in the reverse order. Neutral movies were kept in the middle to facilitate the transition between negative and positive states.

Face stimuli

We generated happy and fearful composite images from 18 faces (9 females) showing a fearful facial expression and the same 18 individuals showing a happy expression (see Fig 1). We computed continua of interpolated (morphed) faces using the Fantamorph software (Abrosoft Co.). Prototypical black and white pictures were taken from the Karolinska Directed Emotional Faces (KDEF) dataset [38]. These prototypical images were used as endpoints to generate a linear morph sequence with 15 steps, with intermediate images changing incrementally

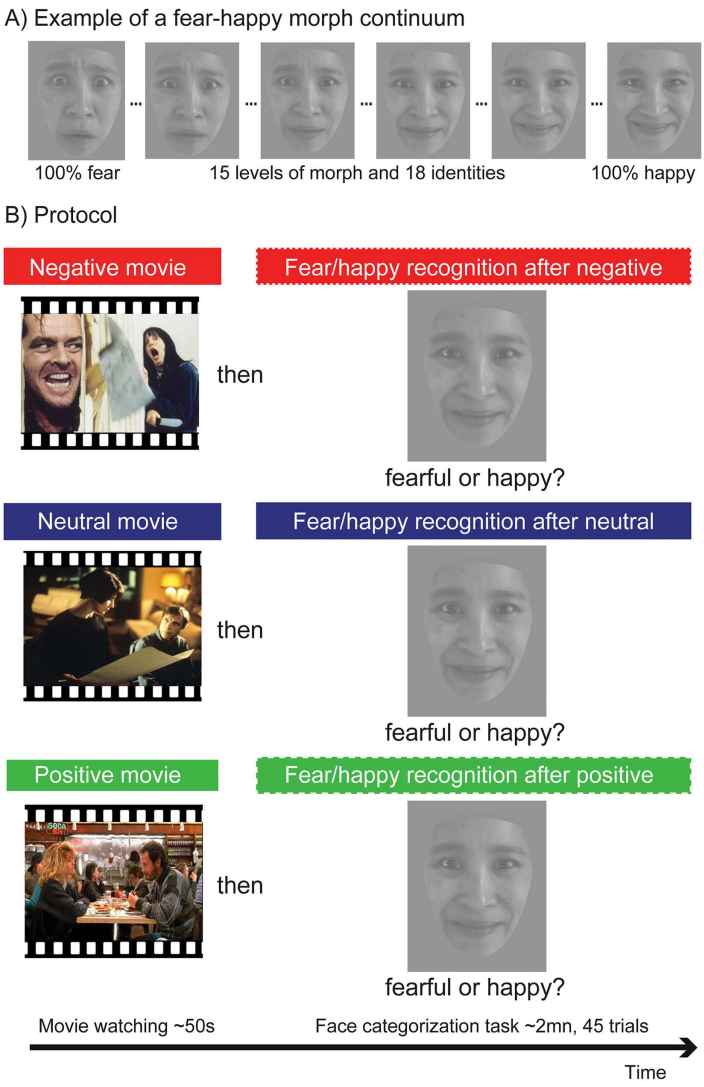

Fig 1. Protocol. A) Example of a fear-happy morph continuum in facial expression, ranging from pure fear to pure happiness. B) During the task, participants watched negative, neutral or positive movie clips, and subsequently performed a decision-making task where they categorized morphed faces as fearful or happy. Note that these face images are examples similar but not identical to the faces presented in the actual tasks which used KDEF faces, and are therefore for illustrative purposes only. We have received informed consent according to Plos guidelines from the individual portrayed here.

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from unambiguously fearful to unambiguously happy, with emotionally ambiguous images in the middle. These 15 steps of morph were selected based on a pilot study (n = 19) to ensure that canonical expressions were recognized well above 75% and that ambiguous morph levels fell in the middle of the morph levels continuum. A grey mask surrounded each face. Luminance and contrast were equated for all faces. Each of the 18 actors * 15 morphs was repeated 3 times across the experiment to appear once in each emotional context, leading to a total of 810 trials. After each movie, we presented 45 semi-randomized trials of the decision-making task so that two consecutive morph degrees of the same actor were never presented in a row.

Each trial began with a fixation cross (500ms), followed by a morphed face (500ms) with the words "FEAR" and "HAPPY" presented below (order changed across subjects), all

displayed on a grey background. Participants were forced to classify the faces as either fearful or happy, as accurately and as fast as possible. Inter-trial interval ranged between 500 and 1000ms. Faces were centered on the screen and subtended 8.6˚ of visual angle vertically and 6.7˚ horizontally.

Analysis of responses

Within participants, the binary categorization of morph stimuli tends to increase monotonically from one response to the other across the morph continuum. The probability of answering "HAPPY" therefore takes the form of a standard sigmoid curve. We estimated the point of subjective equality (PSE) at which each participant was equally likely to classify faces as fearful or happy, by retrieving the morph degree corresponding to a probability of 50% of responding happy. We also estimated the slope of the curve at the PSE, which represents how sharp the distinction between fear and anger is. Data was fitted using a 4-parameter Weibull function. The lower and upper limits of the function were bounded to the interval [0, 1]. The shape parameter, which determines the steepness of the curve, was bounded to be greater than 1 to avoid non-sigmoidal shapes of the function. The slope and the PSE were computed using the drm package [39] implemented in R, specifying that the data was binomial (R Development Core Team, 2014). These parameters were estimated for each individual and for each emotional context, from the responses across the 15 morph degrees. Fits were obtained for all subjects except for one, for whom the fitting procedure could not converge in the fear and neutral contexts due to highly variable responses. This subject was thus excluded from all analyses.

Once PSEs and slopes for each emotional context and each subject were retrieved, we subtracted the value from each emotional context from that of the neutral context to obtain an estimate of PSE shift and slope change. Given our expression axis from fear to happy and our response axis in terms of probability of responding happy, a *rightward* (positive) shift in PSE indicated a bias toward classifying ambiguous faces as *fearful*, whereas a *leftward* (negative) shift indicated a higher propensity to classify ambiguous faces as *happy*. Note that because faces were the same across the 3 emotional contexts, PSE shifts cannot be attributed to differences in stimulus content or expression strength. For slope measurements, a positive (respectively negative) change indicated that sensitivity to discriminate between expressions increased (respectively decreased) between a given emotional context and the neutral context. PSE, slope, and reaction times were analyzed through repeated measure ANOVA and t-tests. Effect sizes were reported as Cohen's d.

Absorption ratings for movie stimuli

After the experiment, participants indicated how much they felt absorbed during each movie on a 10-point Likert scale (i.e. how much they felt emotionally immersed while watching each movie).

Affect questionnaires

After the experiment, participants filled out questionnaires to rate their level of positive and negative mood in the last weeks (PANAS [40]), as well as current state anxiety (STAIS [41]), and depression [42]. In addition, trait anxiety (STAIT) was collected at least one day later. Because of technical reasons, questionnaire data was missing for one subject. Participants' state anxiety scores ranged from 20 to 65 (mean±std 32.3±9.8) and trait anxiety scores ranged from 23 to 69 (40.9±9.3), which fall within the published norms for this age group [41]. Participants' depression scores ranged from 0 to 16 (2.7±3.6), which is also below clinical levels for all subjects. As expected, scores for depression, state anxiety (STAIS), trait anxiety (STAIT), and

negative mood (PANAS negative) were positively correlated between each other (all r>.63, all $p < .001$), and negatively correlated with scores for positive mood (PANAS positive) (all r<-.44 and all $p < .002$), except for the PANAS negative (r = -.25, p = .1). Influence of these variables on interpretation bias was examined using ANOVA and 1-tailed Spearman correlations were used in figures for illustrative purpose. In accordance with the literature on depression and anxiety [20–22], we expected that negative mood, depression and anxiety would be positively correlated with negative interpretation bias for facial expressions.

Results

Effects of transient emotions

We first tested for any significant shift in PSEs following emotional movies, relative to the neutral control condition. Planned t-tests on PSE shift across participants showed that ambiguous faces were more likely to be classified as fearful in the post-negative compared to the post-neutral movie context ($t(42) = 2.21$, $p = .016$, $d = .19$, 1-sided 1-sample t-test, Fig 2A and 2B). In contrast, positive context relative to neutral induced no PSE shift ($p = .6$).

Similar planned t-tests performed on slope changes showed no significant difference in either context relative to the neutral control condition (p's > .13, 1-sample t-test). However, a pair-wise comparison between slope change in the negative versus positive contexts was significant ($t(42) = 2.28$, df(42), $p = .02$, paired t-test). Average change values revealed that the slope (i.e. sensitivity) of the discrimination performance was increased after exposure to negative compared to neutral movies (mean = .07±.28, d = .19), whereas this change was negligible after exposure to positive movies (mean = -.03±.29, d = .11) (see Fig 2B).

Next, we further characterized how the PSE bias observed in the negative context varied as the experiment unfolded. We divided each face perception blocks into first and second halves with respectively 22 and 23 stimuli each (Fig 2C). We re-computed PSE values for every subject for the negative and neutral contexts. We dropped the positive context from this analysis given the absence of results reported above. Because each fit was estimated on half the data, the fit procedure failed in two subjects who were excluded from this analysis. We entered the new PSE values in a repeated-measure ANOVA crossing the factors *time* and *emotion context*. The results confirmed a main effect of emotional context ($F(1,40) = 5.67$, $p = .022$). However, neither time ($F(1,40) = .1$, $p = .74$) nor the time-by-context interaction were significant ($p = .72$), indicating that the negative bias remained comparable during the entire face perception blocks and thus sustained over time.

In addition, we investigated whether absorption during movie watching influenced the PSE shift between emotional and neutral contexts. For negative movies, there was no correlation between the PSE shift magnitude and the difference in absorption between negative and neutral movies (r = -.17, df = 41, p = .28). However, in the positive context, the PSE shift was found to become significantly more positive as absorption in movies increased (r = -.39, df = 41, p = .01, Fig 2D). This suggests that subjects who felt more absorbed in positive movies favored more happy interpretation of ambiguous faces than subjects who were less absorbed. Note that positive and negative movies were rated as more absorbing than neutral movies (respectively $t(42) = 5.1$, $p < .001$ and $t(42) = 11.8$, $p < .001$), and negative movies more absorbing than positive movies ($t(42) = 6.1$, $p < .001$). Note also that the variance of absorption ratings for positive movies (sd = 1.87) tended to be higher than for negative movies (sd = 1.22) even though this difference was not significant (p = .77). This may suggest that interest in positive movies in our sample was more nuanced and variable than for negative movies.

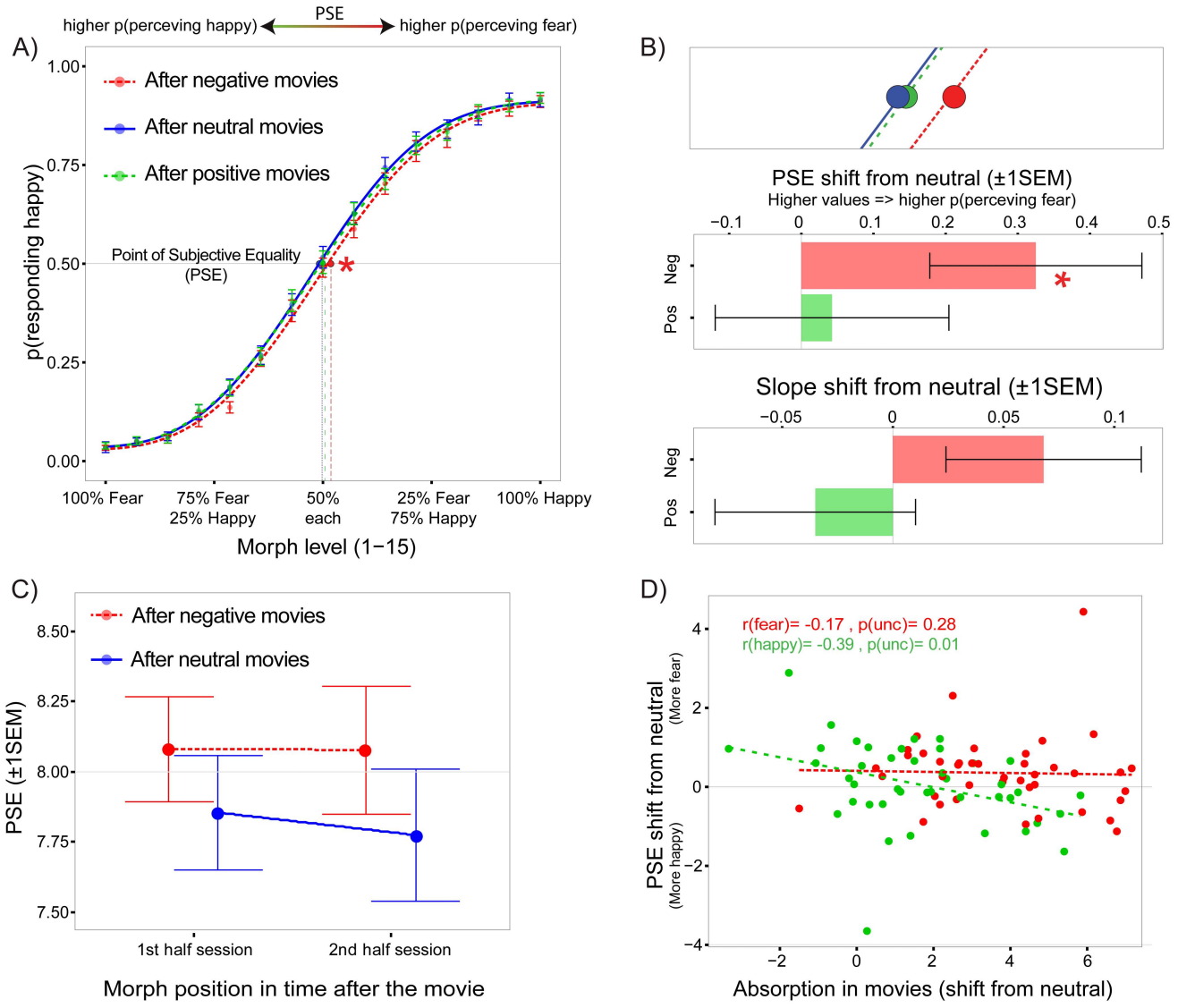

Fig 2. Interpretation bias following transient emotion induction. A) Sigmoid curves illustrating the probability of categorizing morphed faces as expressing happiness across morph levels and emotional contexts. Curve fitting resulted in two parameters for each subjects and each emotional context: the point of subjective equality (PSE), which characterizes the morph level at which the subject is at chance for discriminating happy vs. fearful expressions (also termed interpretation bias), and the slope of the curve at the PSE, which characterizes the sharpness of the decision boundary between happy and fearful faces. B) Top plot: zoom on the group average PSE for each emotional context. Middle plot: After viewing negative movies relative to neutral clips (red), participants increased their propensity to classify ambiguous expressions as fearful. No significant average shift (relative to neutral) was observed after watching positive movies (green). Bottom plot: There was an increase in slope after negative compared to neutral movies. C) Evolution of the bias over time in the negative context revealed that it persisted during the entire decision-making task (~2 minutes). Error represent ±1SEM. D) Correlations between absorption ratings and PSE shifts (for emotional compared to neutral movies) showed that for the positive context, more absorbing movies led to increased propensity to classify ambiguous faces as happy. Note that all statistical tests remained significant after removing two potential outliers with the most positive and the most negative PSE shifts.

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Effects of individual differences in mood, anxiety, and depression

To examine the effect of more persistent affective states and mood on facial expression perception, we ran four separate ANOVAs on the emotion-induced shift that tested respectively for modulations by positive mood, negative mood, depression, and anxiety, using the latter

individual scores as a between-subject variable. These ANOVAs were run on PSE as the dependent variable and with emotional context as a within-subject factor.

These ANOVAs revealed no effect of positive mood (PANAS positive, $p = .4$). In contrast, there was a significant main effect of negative mood (PANAS negative, $F(1,41) = 5.95$, $p = .02$) but it did not interact with contextual factor ($p = .92$). Likewise, the third ANOVA with depression scores (Beck scale) indicated an effect of depression ($F(1,41) = 4.2$, $p = .04$) with no interaction with emotional context ($p = .96$). Finally, concerning anxiety scores (STAI-T and STAI-T), we found significant effects of both state anxiety ($F(1,41) = 12.7$, $p < .001$) and trait anxiety ($F(1,41) = 8.7$, $p = .005$), but again no interaction with emotional context (ps $>.2$). These data suggest that, in our subclinical population sample, the effect of emotion induction was independent of persistent affective background even though the latter did modulate emotion perception. Note that due to the high comorbidity between anxiety and depression, a multiple regression was not adapted to reliably disentangle the respective contribution of depression or anxiety, and it would be unlikely to reveal other results given the lack of significant effects in separate regression analyses. To illustrate the impact of negative PANAS on emotion perception, we divided participants in three equal groups (tertiles) according to the negative PANAS scores and we plotted the psychometric function of the groups with the lowest and highest negative mood scores in Fig 3A).

Reaction times

Finally, we performed a repeated-measure ANOVA on reaction times (RT) during the decision-making task, with emotional context and morph levels as independent factors. Results indicated that RT evolved quadratically with morph levels ($F(1,14) = 261$, $p < .001$, quadratic contrast). This is reflecting more difficult judgments and longer latencies for more ambiguous faces close to the PSE (S1 Fig). The influence of emotional context was marginal ($F(2,84) = 3.06$, $p = .052$). There was no interaction between morph and context ($p = .52$) even though RT for rating emotional faces looked slower in the negative context (mean±SD: 962ms±283) than in the positive (890ms±204) or neutral contexts (921ms±237). Posthoc tests contrasting both emotional contexts confirmed that RT were slower in the positive than in the negative context ($t(42) = 2.12$, $p = .04$, $d = .18$). There was no significant difference between the neutral context and the negative ($p = 08$) and positive context ($p = .4$).

Discussion

In this manuscript, we tested the hypothesis that several minutes of immersion into positive and/or negative emotional movies, may generate sustained affective states that outlast by ~2 minutes the exposure period and subsequently bias the interpretation of face expressions in a perceptual decision making task. In this sense, our work goes beyond recent priming studies by establishing a longer lasting impact of mood induction. We also investigated whether such effects are influenced by individual affect (depression and anxiety) traits. Finally, a key aspect of our study is the use of a psychometric approach to evaluate the processing of emotional faces allowing us to distinguish the source of the effect as a bias versus a change in sensitivity.

Our results demonstrate that transient emotional states modulate the interpretation of ambiguous emotional faces, with a stronger effect after watching negative movies than after positive movies. Induced negative states increased participants' propensity to interpret ambiguous facial expressions in a more negative way relative to induced neutral or positive states. Interestingly, while positive movies did not modulate the interpretation of ambiguous expressions overall, participant's propensity to rate faces as happy increased as their absorption during happy movies increased. In addition, we found that more persistent negative states related

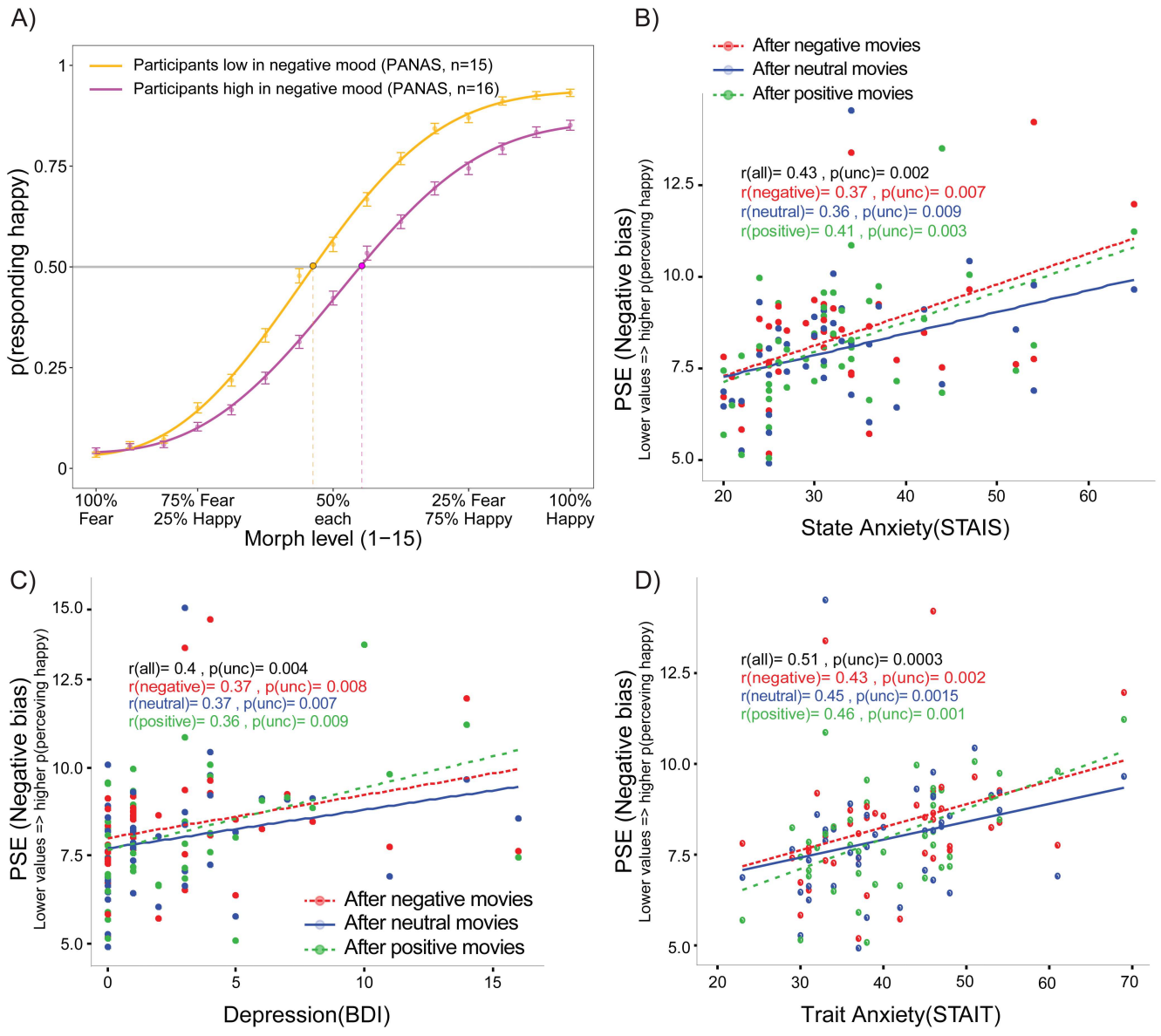

Fig 3. Interpretation bias are strongly influenced by persistent emotional states associated with individual trait differences. A) Subjects with a more negative mood showed a higher propensity to classify ambiguous faces as fearful than subjects with less negative mood (1st and 3rd tertiles of the PANAS negative scale). B-D) Correlations showing that the more individuals' interpretation bias (i.e. PSE) was negative, the higher the state anxiety (B), depression (C), and trait anxiety (D).

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to individual traits, such as negative mood, anxiety, and depression, predicted the magnitude of the negative interpretation bias when judging ambiguous expressions, but did not influence the impact of the transient emotions induced by movies. This confirms that persistent negative affect leads to a tendency to over-interpret ambiguous information as negative [20–22]. The findings reported here therefore support the idea that transient and persistent emotional states 'infuse' cognitive states and influence evaluation in a state-congruent fashion [13]. They further extend previous work demonstrating that high trait absorption is related to enhanced emotional picture processing [33], by showing that state absorption can influence, at least for positive movies, the induction of a subsequent interpretation bias. They also show that such

interpretation bias may remain present over several minutes, well beyond the short durations previously reported in the priming literature (where cue-target intervals of the order of hundreds of milliseconds are typically used).

Thus, these results add to previous evidence that information available during or shortly before perception of a target stimulus can bias its emotional evaluation [17,43,44]. According to affect priming models, emotional states can prime the encoding, retrieval, and selective use of information. They can also influence the evaluation of emotional stimuli and influence social judgments [13,15,16]. For instance, judgments related to quality-of-life, responsibility, future expectations, or political judgments are more optimistic after seeing a comedy, than after seeing a sad or a violent movie [45]. Certain priming procedures have used movies, music, or scripts to elicit emotional experiences. For instance, a previous experiment showed that the categorization of neutral, mildly happy, or mildly fearful faces was slightly influenced by the valence of a just preceding positive or negative IAPS picture [17]. Other experiments using the auditory modality showed that sad emotional states, induced by sad music, increase the propensity to rate ambiguous faces expressing various negative emotions as more negative [46,47], whereas joyful music induces the opposite effect [47,48]. Another experiment suggested that long lasting emotion effects could operate unconsciously by showing that subliminal happy face primes (compared to angry faces) may promote drinking of a pleasurable beverage during a subsequent unrelated task [49].

Our findings counter the idea that affective priming effects dissipate shortly after priming, as in paradigms where emotional primes (e.g. words) are presented for durations shorter than a few hundreds of milliseconds [10]. In such paradigms, it was argued that priming ceased to be detectable when the prime is presented beyond certain durations (typically 300ms). Moreover, these paradigms usually employ reaction time measurements, which may lack the sensitivity necessary to detect changes in affective processing. Note that we observed a global trend towards slower reaction times in the negative context relative to the positive context. A generic slowdown of reaction times in threatening contexts has often been interpreted as reflecting a freezing response or a suspension of ongoing task activity due to increased attentional vigilance towards the potential threat [50]. The reaction times changes were however noisy; an advantage of measuring shifts in interpretation bias, as we do here, is that they offer a very sensitive procedure to detect emotional priming effects. However, because this technique requires collecting decisions on several tens of trials, it can only detect biases that last for at least a few minutes. Our results establish that transient affective biases are not limited, nor stronger, during the immediate period following emotional events, and they may extend over a few minutes, at least when the emotional priming context has been presented for a sufficiently long time (e.g., in short movies here). Further work is needed to understand the relationship between the emotion induction duration, absorption during inducing events, and duration of the subsequently induced interpretative bias.

At the neural level, interpretation biases might result from an interaction between changes in the limbic system and interconnected regions in perceptual pathways and the prefrontal cortex. Notably, activity of the amygdala, a key center for emotion perception and fear processing, is modulated by the emotional information associated with or preceding the presentation of neutral faces [17]. Likewise, watching negative movies enhance subsequent amygdala reactivity to fearful faces, whereas positive movies attenuate it [5,35]. Similarly, when cued by a sentence with a negative context (e.g. he/she lost 500$), faces with a surprised expression produce greater activity in the ventral amygdala and the ventrolateral prefrontal cortex than when cued with positive sentences (e.g. he/she won 500$), while the latter produce stronger activity in the ventromedial prefrontal cortex [51]. Interestingly, Eryilmaz et al. (2011) observed that transient emotions can produce lasting changes in brain connectivity patterns, reflecting a

reconfiguration of large-scale network states ([34], see also [36]). In particular, functional coupling between the amygdala and the ventromedial prefrontal cortex at rest is selectively reduced after watching negative emotional movies, similar to those used here [34]. Also, Pichon et al. (2012) showed that functional connectivity between the amygdala and the orbitofrontal cortex is reduced after priming with negative emotional words [19]. Hence, a modulation of amygdala functioning, together with its connectivity with other prefrontal and temporal regions, may provide a plausible neural substrate for explaining how emotional events influence subsequent affective processing and produce interpretation biases.

Similar to our findings, previous emotion induction procedures have shown that a negative context seems more efficient at priming a negative bias than a positive context is at inducing a positive bias [52–54]. In our study, the higher induction efficiency of negative over positive movies might be related to the fact that negative movies tend to depict universal representations (e.g., violence, death. . .), while positive movies and humor often rely on cultural norms which may vary between social groups and genders. This interpretation also accords with the fact that absorption ratings were generally lower and more variable for positive than negative movies. This suggests that tailoring the positive context to the targeted social groups or individuals, and carefully selecting or creating positive contexts that allow greater absorption, may be an important factor for regulating emotional responses towards more positive outcomes.

Persistent affective states such as mood, anxiety, and depression also impacted interpretation bias for facial expressions, even to a greater extent than transient emotional states (at least 5 times stronger in terms of effect size). Participants with high anxiety or subclinical depression displayed a higher propensity to interpret ambiguous faces as fearful. This is consistent with previous studies showing that depressed subjects display increased attention and memory toward negative stimuli [24,55]. Dysphoric individuals are more likely to classify morphed faces ranging from pure sadness to pure happiness as sad [23], and the magnitude of this bias correlates with their levels of depression, anxiety, and negative mood [56]. Also, anxious patients have a greater attentional vigilance to threatening stimuli and are more willing to interpret ambiguous situations as negative [57]. At the brain level, it is interesting to note that depressed patients show increased metabolic activity and altered grey matter volumes in amygdala-medial prefrontal networks [58], similar to those affected by transient negative priming effects as described above [36]. Hence, chronic dysfunction in this limbic-prefrontal network could lead to the maintenance of negative interpretation biases. Yet, direct evidence linking behaviour to brain function in this domain is still lacking.

However, despite these individual differences, we found no significant correlation between the persistent affective states and the impact of transient emotions on expression interpretation bias in our participants. Given that emotional blunting is frequent in depressed patients [59], whereas heighted emotional reactivity is commonly associated with anxiety [31], we expected a decreased or exaggerated emotion induction effect in subjects with higher depression or higher anxiety scores, respectively. This was not the case. It is worth noting that none of our subjects were highly depressed or clinically anxious. Sampling over a wider spectrum of depression or anxiety levels might be necessary for testing this hypothesis.

In conclusion, the present work shows that both transient and persistent affective states influence the way we perceive emotionally ambiguous information. The decision-making task we introduce here shows enough sensitivity to repeatedly detect shifts in emotion expression as a function of different emotional contexts. In addition, given that this perceptual measure correlates well with anxiety and depression scores, it could be used to provide a quantitative and implicit evaluation for the outcomes of an intervention. For example, such a test could be used to assess the transfer of learning after cognitive therapy, which aims to train patients to favor positive interpretations of situations over negative ones [60]. An interesting extension of

the present work would be to better characterize how the duration of priming events and the absorption experienced during them may determine the strength, persistence, and volatility of the subsequently induced biases. It would also be interesting to assess whether repeated exposures to specific priming contexts (such as emotionally charged videogames) could lead to more persistent interpretation biases.

Supporting information

S1 Fig. Mean reaction times across morph levels revealed longer latencies for more ambiguous expressions around the PSE. Reaction times in the negative context were slower than in the positive context (negative: red dotted line, neutral: blue plain line, positive: green dotted line).
(TIF)

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