The influence of social context on food-evoked emotion

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Abstract

Emotion measurement has seen exponential growth in recent years as consumer and sensory scientists realise that our emotional responses to food are better at predicting choice and purchase behaviour compared to hedonic or sensory evaluations alone. However, despite a large body of evidence pointing to the context-dependent nature of emotion, insufficient attention has been placed on quantifying the impact of contextual variables on consumption emotion. In this thesis, I first investigate the effects of timing, location and social setting on explicit emotional responses using a survey methodology. It was found that social meals amplified positive emotion relative to solitary meals, and that sociality and location had a larger effect on self-reported emotion compared to meal timing. I then focus on social context effects on implicit emotion using facial electromyography as a measure of the expressive component of emotion. In two closely related experiments, participants' facial affective responses were recorded as they viewed and rated food images in the presence of a researcher, a friend, or a stranger. Analyses revealed that facial muscle activity indicative of a disgust response was inhibited in the presence of a researcher but amplified in the presence of a co-acting stranger. These findings are discussed with reference to Basic Emotions Theory and the Behavioural Ecology View of facial expressions. Finally, in exploratory analyses, I consider temporal patterns of facial responding and discuss their relationships with social context and subjective preference. The findings presented in this thesis may hopefully serve as a springboard for further investigations into contextual influences on food-evoked emotion.

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Preface

This thesis takes the form of a PhD by publication format. Study One (chapter 2) was accepted for publication by *British Food Journal* in February 2020, Study Two (chapter 3) was published by *Food Research International* in December 2019, and Study 3 (chapter 4) was published by Food Quality and Preference in December 2019. As the author of these articles, I retain the right to include them in my thesis or dissertation, provided it is not published commercially. The final two chapters (chapters 5 and 6) of this thesis present exploratory findings and as such, they have not been submitted for publication. However, chapter 5 was presented at the 46th Annual Conference of the Australasian Society for Experimental Psychology in April 2019. All three empirical studies were peer reviewed and judged to be low risk, and therefore were not presented before an ethics board.

A data article describing the methods and data from Study Two in detail was published in *Data in Brief* in their April 2020 issue. This has been included in Appendix F.

The work presented in this thesis is my own. Under the supervision of Dr. Peter Cannon and Dr. Michael Philipp, I designed the survey and experiments, collected data, performed statistical analyses, and wrote all content presented in this thesis.

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1 Introduction: Social context and food-evoked emotion

Eating is a social activity; meals are prepared and shared with family and friends, social gatherings always involve food and drink. The psychological literature has, so far, focused on the relationship between social presence and eating behaviour but has yet to turn its attention to how the sociality of a meal influences our emotional experience of it. The topic of food-evoked emotion is naturally also of interest to the field of consumer and sensory science. The proliferation of food options available to us today has made it increasingly difficult to predict purchase behaviour based on consumer ratings of liking alone. Fortunately, measures of food-evoked emotion have been shown to excel in this aspect over liking and acceptability measures. This introduction chapter will discuss the literature on social context, emotion theory, and emotion measurement in consumer research.

1.1 Social context

We behave differently in public than we do in private. The presence of others invokes interpersonal motives, social norms and demands on attentional resources that impact on our thoughts, feelings, and actions. This section provides an overview of how social context influences our behaviour and emotions, outlining the gap in the literature concerning social context and consumption emotions.

1.1.1 Social context on emotion

The presence of others has been shown to influence our emotional responses to visual, auditory, olfactory and taste stimuli (eg. Fridlund, 1991; Jäncke & Kaufmann, 1994; Liljeström, Juslin, & Västfjäll, 2013). Amongst all the different types of social relationships that exist, the emotional effects of the presence of a close friend or partner is the best understood. These effects appear to fall under two main categories - a familiar presence attenuates our emotional response to stress and threats and amplifies pleasant experiences.

Perhaps the most well-known example in the first category, Coan, Schaefer, and Davidson (2006) measured women's threat response activation using fMRI as they received mild electric shocks while alone, holding the hand of their spouse, or holding the hand of a male stranger. Women's neural threat responses to anticipated shocks were reduced when holding the hand of a stranger, compared to being alone, and even further reduced when holding the hand of their spouse. This finding has been substantiated by a subsequent study by the same research group (Coan, Beckes, & Allen, 2013), and by other investigations of child-caregiver pairs (Conner et al., 2012; Lougheed, Koval, & Hollenstein, 2016). Stress responses are also reduced in the presence of close others (see Uchino, Bowen, de Grey, Mikel, and Fisher (2018) for a review). Cardiovascular markers of stress, such as heart rate and blood pressure, in response to giving a speech or solving difficult arithmetic problems were decreased when a friend was present (Bonfiglio, 2005; Edens, Larkin, & Abel, 1992; Kamarck, Manuck, & Jennings, 1990; Kors, Linden, & Gerin, 1997; Well & Kolk, 2008).

In the second category, studies show that sharing an experience with another person tends to amplify our emotional responses to that experience. For example, music listeners experience more intense self-reported emotions and increased skin conductance and heart rate when listening with a close friend or partner compared to listening alone (Liljeström et al., 2013). Another experimental study measured participants liking and realness ratings of visual stimuli while viewing alone, with an unfamiliar co-viewer or with a familiar co-viewer (Boothby, Smith, Clark, & Bargh, 2017). Liking and realness ratings increased when the images were viewed with a friend, and decreased when viewed with a stranger, compared to the alone condition. Reis, O'Keefe, and Lane (2016) also illustrated this effect using diary studies, where they found that participants reported more high- and low-activation positive affect when describing shared fun than when describing solitary enjoyment. Studies have found that negative emotional experiences are amplified by the presence of others too. Martin et al. (2015)

observed that people reported a cold pressor task to be more painful when they experienced it with a friend, compared to others who underwent the task alone or with a stranger. In a similar vein, Shteynberg et al. (2014) found that self-reported negative feelings towards scary advertisements, and sad images and videos were greater when viewed in a group setting, compared to when viewed alone.

The influence of an unfamiliar presence or strangers on our emotional responses appear to be less straightforward. In Coan and colleagues' (2006) study mentioned above, holding the hand of a stranger reduced neural threat responses but less so than holding the hand of a close other. In Boothby and colleagues' (2017) study also discussed above, a co-viewing stranger reduced liking evaluations of images. Lee and Wagner (2002) found that participants smiled more while speaking of both positive and negative experiences when the experimenter was present compared to when they were alone, suggesting that positive emotions are facilitated by and negative emotions inhibited by an unfamiliar social presence. This effect was observed even when the social presence was a mere computer simulation (Philipp, Storrs, & Vanman, 2012). However, other studies have observed that an unfamiliar presence inhibits both positive and negative emotion towards images (Buck, Losow, Murphy, & Costanzo, 1992) and odours (Kraut, 1982), or facilitates both positive and negative emotion (Jäncke & Kaufmann, 1994). It has been suggested that the complexity of social context effects are due to differences in underlying relational goals (Greenaway, Kalokerinos, & Williams, 2018). Depending on the situation, we may be inclined to compete, cooperate or affiliate with our interaction partner, resulting in differing levels of dampening or amplification of our emotional responses.

The social context of an experience exerts an influence on our emotions even when it is implicit or imagined. Fridlund et al. (1990) recorded facial muscle activity and self-report measures of emotion while participants imagined doing enjoyable activities alone or with someone else. It was observed that smiling and self-reported happiness was greater while high-sociality situations were being imagined. In another study, Fridlund (1991) asked participants to view funny video clips while under the impression that their friend was doing the same in another room (implicit co-viewing condition) or while under the impression that their friend was engaged in a different experiment (implicit irrelevant task condition). The study demonstrated the effect of the 'implicit audience'; participants smiled more in the implicit co-viewing condition compared to the implicit irrelevant task condition despite no detected differences in self-reported emotion.

In summary, there is strong evidence that social context influences our emotional responses to a variety of stimuli. The presence of familiar others appears to have an overall positive effect on emotion, while the effect of the presence of an unfamiliar other is less understood.

1.1.2 Social context on consumption behaviour

Social context influences our consumption behaviour. People reliably eat more when dining with others and this phenomenon is known as the social facilitation of eating (Clendenen, Herman, & Polivy, 1994; De Castro, 1990, 1991; De Castro & Brewer, 1992). From an extensive series of diary studies, de Castro and colleagues (1997) observed that people spontaneously chose meals that were 44% higher in total calories when they ate with others compared to when they ate alone. An experimental study found a similar-sized effect; participants assigned to eat in groups of three or four ate 41% more than participants assigned to eat alone (Berry, Beatty, & Klesges, 1985). Clendenen et al. (1994) found that social diners ate up to 90% more than solo diners. In their diary studies, de Castro and colleagues also observed that the social facilitation effect occurred regardless of the meal, the location, the day of the week, and whether or not alcohol was served with the meal (De Castro, 1990, 1991). Social presence had the largest impact on food intake over all other situational factors studied (De Castro, 1995).

The mechanisms behind the social facilitation of eating are thought to be increased meal duration (De Castro, 1990, 1995), social modelling (Cruwys, Bevelander, & Hermans, 2015), and distraction (Hetherington, Anderson, Norton, & Newson, 2006). De Castro observed that people took longer to eat when they ate with others than when they ate alone and hypothesized that this greater exposure to food cues explained the increased food intake. Pliner, Bell, Hirsch, and Kinchla (2006) investigated this 'time dilation' hypothesis with an experiment where the meal duration was pre-determined. Participants were served lunch alone, or in groups of 2 or 4, and were given either 12 minutes or 36 minutes to finish their meal. No effect of group size emerged, but participants ate more in the longer meal duration condition, suggesting that the social facilitation effect is driven by increased meal duration.

Another proposed explanation is social modelling. People tend to adapt their food intake to that of others (Cruwys et al., 2015). In one of the earliest studies on social modelling, Nisbett and Storms (1974) observed that participants ate more when a confederate posing as a another participant ate more, and ate less when the confederate ate less. Since then, this effect has been replicated numerous times. A recent meta-analysis estimates the social modelling effect to be large ($r = .39$) and remarkably robust across variations in observational and experimental methodologies (Vartanian, Spanos, Herman, & Polivy, 2015). In these studies, the confederate is communicating the norms for food intake, however, the effect persists even when participants are simply given a written indication of how much food previous participants have eaten (Feeney, Polivy, Pliner, & Sullivan, 2011). It is theorized that eating with others increases the salience of higher food intake norms, resulting in increased food intake (Herman, Roth, & Polivy, 2003; Higgs & Thomas, 2016).

A third possible mechanism of action is distraction. Social interaction during meals may distract us from monitoring and restricting our own food intake. Bellisle and Dalix (2001) illustrated this with a within-subjects experiment where subjects ate alone, with instructions to attend to their meal (attention), with instructions to attend to a recording of a detective story (distraction), and in a group of four other participants. Participants ate the most in the distraction condition, but energy intake did not differ between the group and alone conditions. In a similar experiment, Hetherington et al. (2006) recorded the food intake of participants eating a buffet-style lunch alone, alone while watching TV, with two friends, or with two strangers. Participants ate the most with friends (18% more than alone) and while watching TV (14% more than alone), suggesting that distraction from attention to food might underlie a signification portion of the social facilitation effect.

The social facilitation effect appears to be restricted to close friends and family. In Hetherington and colleague's (2006) study mentioned above, energy intake did not differ between the sessions where participants ate alone and where they ate with strangers. Comparably, Mekhmoukh, Chapelot, and Bellisle (2012) did not find differences in food intake between teenage boys who ate alone, and who ate in a group of schoolmates they were familiar with but not personal friends. Other studies have found that the presence of strangers does facilitate food intake, but not as much as the presence of friends (Clendenen et al., 1994), or that the presence of strangers actively suppresses food intake (Bellisle, Dalix, Airinei, Hercberg, & Péneau, 2009; Salvy, Jarrin, Paluch, Irfan, & Pliner, 2007). In a comprehensive review of studies on social influences on eating in adults and children, Salvy and Pliner (2010) suggest that the absence or attenuation of the social facilitation effect when eating with strangers is likely due to impression management.

Social context also exerts a considerable influence on eating patterns and food choice. Obesity clusters within social networks (Badaly, 2013; Christakis & Fowler, 2007) and disordered eating behaviours are subject to influence from friends and family (Paxton, Schutz, Wertheim, & Muir, 1999; Salvy, De La Haye, Bowker, & Hermans, 2012). Given the sizeable effect of social context on consumption behaviour, it is likely to exert some influence on consumption related emotion as well.

1.1.3 Social context on consumption emotions

The influence of social context on consumption behaviour is well-established; we eat more and spend more time eating when we eat with others. However, the effect of social context on food-evoked emotion and food preference has yet to be analysed to an appreciable degree. Qualitative inquiries into food-related emotion suggest that dining in company is a critical factor in promoting meal enjoyment and positive feelings. For example, Brown, Edwards, and Hartwell (2013) report that eating lunch with others in a university cafeteria setting enhanced the emotional experience of the meal, and Piqueras-Fiszman and Jaeger (2015b, 2015c) found that participants rated the company during a meal as the most important aspect contributing to a memorable meal, even more so than the actual food and drink consumed. In studies that have used facial expression as a measure of emotional valence, it was revealed that both adults and children demonstrate increased facial displays to pleasant and unpleasant odours in the presence of others (Gilbert, Fridlund, & Sabini, 1987; Jäncke & Kaufmann, 1994; Soussignan & Schall, 1996). These studies suggest that the presence of others might have an amplification effect on consumption emotions.

It has not yet been investigated if the presence of familiar and unfamiliar others influences consumption emotions to different extents. A series of experiments conducted by Boothby and colleagues (Boothby, Clark, & Bargh, 2014; Boothby, Smith, Clark, & Bargh, 2016) found that the presence of a co-experiencer increased sensory and hedonic ratings of chocolate, but only if the co-experiencers were socially proximate. We expect that this pattern will hold true for emotion ratings and emotional facial expressions as well.

To conclude, social context influences emotion and consumption behaviour, and there is some evidence to suggest that it influences consumption emotions as well. Investigations of this effect should also take into consideration the relationship between the experiencer and their audience.

1.2 Emotion theory

There is currently no scientific consensus on a general theory of emotion. The four dominant theoretical perspectives on emotion are evolutionary accounts, the sociodynamic model, the conceptual act theory, and appraisal theories. This section will first discuss the main tenets of each perspective and briefly review their supporting evidence. It will then explore these theoretical accounts as they relate to facial expression in particular.

1.2.1 Evolutionary Accounts

Evolutionary accounts view emotion as functional adaptations to significant recurrent stimuli. The central elements of evolutionary accounts are the ideas that emotions are innate, universal, dynamic, multi-componential and that each emotion is a discrete functional unit (Nesse, 1990; Tracy, 2014). As emotions are posited as universal human adaptations, it should be observed that the presentation and recognition of basic emotions is stable across cultures. Evidence for this consistency was accumulated by Ekman and Friesen (1969) in a study of cross-cultural emotion recognition. They presented subjects from the United States, Brazil, Japan and Argentina with photographs of adults and children displaying emotional facial behaviour and found that subjects from all cultures used comparable words to identify those expressions. This finding was replicated with subjects from the preliterate Fore group of New Guinea (Ekman & Friesen, 1971). Further corroboration of the innateness and universality of displayed emotion was found by a study of pride and shame displays in blind and congenitally blind athletes (Tracy & Matsumoto, 2008). The authors coded facial and bodily behaviour from photographs of International Judo Federation athletes taken immediately after their match. Even though they had never seen facial expressions in others, the athletes displayed pride behaviours in response to wins and shame behaviours in response to defeat. These findings that facial expressions are consistent across cultures and displayed appropriately in the blind provide strong support for evolutionary accounts of emotion.

1.2.2 Sociodynamic Model

The sociodynamic model conceives of emotion as emergent from the social context, which they in turn shape and alter (Boiger & Mesquita, 2012; Butler, 2011; Mesquita & Boiger, 2014; Parkinson, 2012). Unlike evolutionary accounts, where the functionality of an emotion is tied to its evolutionary history, the sociodynamic model situates the function of an emotion in the three levels of sociocultural context it is embedded in: moment-to-moment interactions, relationships, and the wider cultural environment.

The dynamic progression of emotions is closely tied to developments in conversation and non-verbal behaviour in interpersonal interactions. Gottman, Swanson, and Murray (1999) observed that spouses' subjective experiences and physiological markers of anger increased and decreased with each conversational turn depending on whether their partner reciprocated defensively or with compassion. By the same token, Heerey and Kring (2007) showed how a non-socially anxious individual paired with a socially anxious individual gradually declined in positive affect in line with their interaction partner's fidgeting and assurance seeking. Emotions and their constituent components are expected to vary based on the relationship between interaction partners. For example, the anger experienced and expressed towards one's manager would be very different from the anger towards one's child. Empirical findings support this relational variation in emotion. In a study on anger, Van Coillie, Van Mechelen, and Ceulemans (2006) found that people more readily displayed angry behaviour when it was in directed towards someone of low status than to someone of high status. Emotions are also contingent upon the larger sociocultural context. Boiger, Mesquita, Uchida, and Barrett (2013) investigated perceptions of anger and shame in the United States and Japan. Anger is an acceptable emotion in the United States but an implicitly inappropriate one in Japan; the reverse is true for shame. They found that Japanese participants were more likely to associate daily emotional events with feelings of shame while American participants were more likely to associate them with feelings of anger, highlighting the influence of socio-cultural norms on the experience of emotion, and providing evidence against an exclusively evolutionary account.

1.2.3 Conceptual Act Theory

According to the Conceptual Act Theory (CAT), emotions are not biologically or psychologically distinct mental states but rather are conceptual categories of shared meaning that we use to make sense of our own and others' behaviour (Barrett, 2006, 2013, 2014; Lindquist, 2013). This model predicts large variations in emotional experience within each emotional category, within individuals and across cultures and is supported by the literature in this respect (Ceulemans, Kuppens, & Van Mechelen, 2012; Kuppens, Van Mechelen, & Rijmen, 2008; Kuppens, Van Mechelen, Smits, De Boeck, & Ceulemans, 2007). The diverse patterns of brain activity from neuroimaging studies also point towards a view of emotions as semantic representations (Kassam, Markey, Cherkassky, Loewenstein, & Just, 2013; Naselaris, Prenger, Kay, Oliver, & Gallant, 2009; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011).

1.2.4 Appraisal Theories

Appraisal theories have as their focal point the interaction between the internal or external stimulus and the emotion response; this interaction is called an appraisal (Frijda, 1988; Lazarus, 1991; Roseman, 2013; Scherer, 2009). According to appraisal theories, individuals evaluate stimuli along the dimensions of novelty, intrinsic pleasantness, goal relevance, goal congruence, agency, control and outcome probability (Scherer, 2009). These evaluations are predicted to have specific effects on each component of the emotion response and occur in a sequential manner. Studies measuring heart rate, facial and vocal behaviour and brain activity have all found support for these predictions (eg. Aue, Flykt, & Scherer, 2007; Chrea et al., 2009; Johnstone, van Reekum, Hird, Kirsner, & Scherer, 2005). Lanctôt and Hess (2007), for example, manipulated intrinsic pleasantness and goal conduciveness of stimuli while recording participants' facial reactions. They found that facial reactions occurred earlier for intrinsic pleasantness manipulations compared to goal conduciveness manipulations; supporting the sequential nature of appraisals. Also in support of sequential appraisal processes, an EEG study found evidence that appraisals of novelty and intrinsic pleasantness occurred before goal conduciveness (Grandjean & Scherer, 2008).

In summary, while the four dominant perspectives differ on their ideas of emotion emergence and causality, they agree that emotions are functional, dynamic and multi-componential. Nesse (2014) suggests that these not be thought of as competing theories, but as components that work together to address the complex concept that is emotion.

1.2.5 Theoretical accounts of facial expression

Given its close schematic association with emotion, the debate on the causality and function of facial expression has closely mirrored that of general emotion theory. The discourse has been most impassioned between the emotion-expressive and the social-communicative perspectives, with appraisal theories attempting to transcend both positions.

The emotion-expressive account, as best encapsulated by Ekman and Friesen's (1969) Neurocultural Theory, posits that facial expressions express felt emotion. Basic or traditional facial expressions are seen as arising from innate "Facial Affect Programs" (Tomkins, 1962) and are subject to culturally-defined display rules which explain the observed variation in presentation between and within individuals. Support for this theory was found in a series of studies reporting high consistency in the emotion recognition of faces across cultures (Boucher & Carlson, 1980; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969). The overlap of facial behaviour in primates and humans (Chevalier-Skolnikoff, 1973) and the conventionality of facial expression in those born blind and deaf (Eibl-Eibesfeldt, 1973) also point to the biological underpinnings of facial expression. However, recent reviews have contrarily concluded low coherence between facial expression and basic emotions (Camras, Malatesta, & Izard, 1991; Nelson & Russell, 2013; Reisenzein, Studtmann, & Horstmann, 2013). Parkinson (2013) suggests that facial affect program expressions, instead of being universally determined, could just as easily reflect patterns of relational engagement.

The social-communicative perspective is led by Fridlund's (1992) Behavioural Ecology View and defines facial expression as a means of communicating social motives or behavioural intentions, as opposed to being reflective of subjective feeling. Naturalistic studies reveal that Olympic gold medallists (Fernández-Dols & Ruiz-Belda, 1995), Judo competition winners (Crivelli, Carrera, & Fernández-Dols, 2015), bowlers and soccer fans (Ruiz-Belda, Fernández-Dols, Carrera, & Barchard, 2003) generally display expressions of pride and happiness in response to success only in social interaction situations, emphasizing the necessity of a receiver for facial displays to reach perceptibility (see Fernández-Dols & Crivelli, 2013 for a review). Extensive laboratory evidence of audience facilitation of facial expression both in adults (Bavelas, Black, Lemery, & Mullett, 1986; Chovil, 1991; Hess, Banse, & Kappas, 1995; Schützwohl & Reisenzein, 2012; Wagner & Smith, 1991) and children (Jones, Collins, & Hong, 1991; Jones & Raag, 1989; Schneider & Josephs, 1991) and audience inhibition of expression (Kraut, 1982; Matsumoto & Kupperbusch, 2001) also provide a compelling case for the social-communicative position. Critics of this perspective draw attention to the fact that, instead of merely communicating norms and intent, facial behaviour is influenced by social presence in highly complex ways, such as mimicry, countermimicry, contagion and synchronization (Hatfield, Cacioppo, & Rapson, 1994; Hess & Blairy, 2001; Lanzetta & Englis, 1989; Stel & van Knippenberg, 2008).

In componential appraisal theories, driven by Scherer's (1984, 1987, 1992, 2001, 2005, 2009) prolific work on the topic, facial expressions are but one component of the full emotion process, interacting dynamically with other components via a series of sequential appraisals. Facial expressions influence and are influenced by physiological changes, preparations of motor actions and the production of social signals (Scherer & Ellgring, 2007). The complexity of the emotion process reflects the complexity of facial displays, the cumulative result of moment-to-moment changes in appraisals. Studies have shown that dynamic animations of facial expressions based on the theoretical temporal sequence of appraisals increase emotion recognition rates and reduces participant confusion compared to static pictures of facial displays (Krumhuber, Kappas, & Manstead, 2013; Nelson & Russell, 2014; Wehrle, Kaiser, Schmidt, & Scherer, 2000). To investigate the relationship between appraisals and changes in facial expression, Wehrle (1992, 1995, 1996) developed an automated facial coding system linked to a computer game in which situations and characters can be manipulated to engage players in appraisals of novelty, goal relevance, goal obstruction, coping and so on. The software was able to predict emotional responses and identify individual appraisal tendencies, in support of sequential processing (Kaiser & Wehrle, 2001).

Given the wealth of research in support of both the emotion-expression and the social-communicative perspectives, Hareli and Hess (2017) conclude that facial expressions are a manifestation of both the underlying emotion and the social communication intent. Appraisal theories serve as a reminder to consider the wider emotional response.

1.3 Emotion measurement in consumer research

Explicit emotion is commonly described as an individuals' conscious awareness of an emotional state while implicit emotion is an emotional state that occurs without conscious awareness but manifests itself in the persons' thoughts and behaviour nonetheless (Kihlstrom, Mulvaney, Tobias, & Tobis, 2000). The consumer and sensory science field utilises a range of explicit and implicit emotion measurement tools to record consumers' emotional responses to food stimuli. This section will review the most commonly used methods with an emphasis on facial electromyography as the chosen methodology for the present research project.

1.3.1 Explicit emotion measurement

The majority of explicit emotion measurement tools in consumer and sensory science research are in the form of questionnaires that make use of a pre-defined emotion lexicon. One of the first emotion lexicons developed specifically for consumer product testing was Richins (1997) Consumption Emotion Set (CES). Richins observed that consumer researchers at the time were largely using emotion measures that had been developed to capture the emotional experience in response to advertising (eg. Aaker, Stayman, & Vezina, 1988; Batra & Holbrook, 1990; Edell & Burke, 1987) or environmental stimuli (eg. Mehrabian & Russell, 1974), and while useful in their respective contexts, were not appropriate for assessing consumption emotions. Derived from open-ended surveys, the CES consists of 47 emotion terms frequently experienced in consumption situations, grouped into 7 clusters.

While the CES excelled at assessing emotions in a broad range of consumption contexts, other researchers identified the need for domain- and product-specific lexicons. The Geneva Emotion and Odor Scale (GEOS) (Chrea et al., 2009) and its derivative, ScentMove (Porcherot et al., 2010), were developed specifically to assess consumers' emotional response to odors. Starting with 480 emotion terms from emotion literature, the authors successively reduced the number of terms via consumer surveys and factor analysis to arrive at the final 36 terms in the GEOS and 18 in ScentMove. EmoSemio (Spinelli, Masi, Dinnella, Zoboli, & Monteleone, 2014), was developed by Italian researchers using the Repertory Grid Method for the purpose of discriminating between chocolate hazelnut spreads. The GEOS and EmoSemio highlighted the importance of considering language and cultural context in the creation of consumer emotion lexicons.

Perhaps the most widely used consumer emotion questionnaire at the time of writing is the EsSense Profile created by King and Meiselman (2010). Their concern was that the majority of existing standardized mood and emotion questionnaires were designed for use in clinical settings and as such, had an emphasis on negative emotion terms. However, due to the fact that food products are designed to be appealing, the emotional experience of food products tends to have a strong positive bias (Desmet & Schifferstein, 2008). King and Meiselman started with emotion terms from existing mood questionnaires, POMS (McNair, Lorr, & Droppleman, 1981) and MAACL-R (Lubin et al., 1986), and from internet surveys in which respondents were asked to describe how they felt when they consumed their favourite and least liked foods. The final 39 terms in EsSense Profile were then selected based on frequency of use and consumer feedback on appropriateness to food testing. The EsSense Profile and its abbreviated version, EsSense 25 (Nestrud, Meiselman, King, Lesher, & Cardello, 2016), have been used to evaluate a wide range of consumer products and provides excellent product discrimination even when samples are highly similar (Gutjar, de Graaf, et al., 2015).

Recent work has also been done on consumer-defined emotion lexicons. Ng, Chaya, and Hort (2013) generated a lexicon for use with blackcurrant squashes by interviewing consumers using a modified repertory grid method. The authors found that while the consumer-defined lexicon was similar to the EsSense Profile in terms of discriminability, it offered additional insights into consumers' emotional experience. For example, the term "guilty pleasure" in the consumer-defined lexicon discriminated between products whereas "guilty" in the EsSense Profile did not. In another study, Jaeger, Cardello, and Schutz (2013) asked consumers to freely list their emotions or feelings in response to food names and sampled food items. Their study revealed that consumers listed much fewer words than the 39 in the EsSense Profile and that there was only a 37% (food names) and 47% (tasted food) overlap of consumer-generated words and

EsSense Profile terms. The authors urge for more research to clarify how consumers engage with questionnaire-based emotion measures.

In addition to verbal emotion lexicons, visual emotion measurement instruments such as PrEmo (Desmet, Hekkert, & Jacobs, 2000) and Image Measurement of Emotion and Texture (IMET) (Collinsworth et al., 2014) have also been developed for product testing and consumer research. PrEmo consists of 9 positive and 9 negative emotions displayed by an animated cartoon character. Beyond its efficacy in product discrimination, PrEmo was found to predict food choice more accurately than verbal emotion measures (Dalenberg et al., 2014). The authors suggest that by not requiring subjects to verbalize their felt emotion, PrEmo responses are faster and more intuitive than verbal emotion questionnaires. Citing a similar rationale in the development of IMET, Collinsworth and colleagues measured subjects' emotional responses to beverage and cheese samples using predefined images and subject-selected images associated with 12 universal emotions. The method proved to be useful in capturing emotions and changes in emotion.

The convenience of explicit emotion measurement tools has made them invaluable to product emotion research. However, they are not without methodological and theoretical shortcomings.

A protocol analysis of EsSense Profile using think-aloud and thought-listing tasks (Jaeger et al., 2013) revealed that while participants found listing their emotions easy, they also found it strange or weird. Participants elaborated that this was because some emotion words were not strongly felt or relevant in response to food stimuli or because they were confused over the meanings of some words. In comparison, participants did not find hedonic or sensory tasks strange. There was also the tendency to report that the EsSense Profile task became boring and repetitive over time. In a review of methodological considerations in emotion questionnaire research, Jaeger and Cardello (2016) describe how factors such as emotion word list length, emotion word order, questionnaire instructions, time-of-day and number of samples all have marked effects on reported emotions and emotion intensity. These insights question the validity of emotion profiling tasks as a true representation of consumers' emotional responses to the products they are evaluating.

Over the past few decades, emotion theory has moved away from the conceptualisation of emotion as static and discrete states (Ekman, 1992; Izard, 1992) and towards a view of emotion as a dynamic and multi-componential process (Scherer, 2001, 2009). Consumer emotion measurement, however, has not mirrored this paradigm shift. Consumers' emotion responses on fixed-choice questionnaires are inherently retrospective in nature and cannot reflect the dynamic unfolding of the emotion process over time. Witherington and Crichton (2007) liken this to attempting to measure the speed of a car by analysing the tire marks left on the road after it has come to rest. The development of the Temporal Dominance of Emotion (TDE) method (Jager et al., 2014) is a small step forward in addressing this limitation. TDE involves presenting participants with a list of emotion words on a computer screen during engagement with a product sample. The participant is tasked with selecting the emotions they feel as most dominant continuously over the trial. Furthermore, by relying solely on self-reports, explicit emotion measurement can only capture the subjective experience component of emotion. Component theories of emotion postulate that in addition to subjective experience, there are four other fundamental components that underlie the emotion process – cognitive, neurophysiological, motivational and expressive (Scherer, 2005). These component processes are not readily available to conscious awareness and thus go undetected by explicit measurement methods.

1.3.2 Implicit emotion measurement

The case for implicit emotion measurement in consumer research is strong. Food choice is largely reliant on simple heuristics as opposed to rational thought (Schulte-Mecklenbeck, Sohn, de Bellis, Martin, & Hertwig, 2013) and similarly, eating behaviours are primarily habitual as opposed to requiring explicit attention (van't Riet, Sijtsema, Dagevos, & De Bruijn, 2011).

To illustrate the impact of implicit emotion on consumption, Winkielman, Berridge, and Wilbarger (2005) presented participants with happy and angry faces subliminally and then asked them to pour, drink and rate an unfamiliar fruit beverage. They found that when primed with happy faces, participants, especially thirsty ones, poured and consumed more of the beverage and were even willing to pay more for it. This all occurred without any conscious change in self-reported feelings, substantiating the influence of implicit emotion on consumption behaviour.

A recently developed emotion measure, the emotive projection task (EPT) (Mojet et al., 2015), uses a visual questionnaire format to tap into implicit emotion. In the EPT, participants label photographs of people with six positive and six negative personality traits after consuming the test sample. Their judgements are taken as an indication of the positive and negative implicit emotions aroused by the sample. While promising, more work must be done to validate this novel implicit emotion measure. Apart from the EPT, implicit emotion measurement methods generally fall into 3 categories – neurophysiological, autonomic and behavioural.

Neurophysiological measures such as electroencephalography (EEG), magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) have been used to assess implicit emotion. However, due to the high cost of equipment and demands on participants, these measures are preferentially employed in investigating the differences in hedonic responses to food between healthy and clinical populations (eg. Ng, Stice, Yokum, & Bohon, 2011; Santel, Baving, Krauel, Münte, & Rotte, 2006; Schag, Schönleber, Teufel, Zipfel, & Giel, 2013) rather than as a tool for differentiating consumer products. When deciding on neurophysiological measures, researchers face a trade-off between temporal resolution and signal localisation. EEG and MEG offer high temporal resolution but low spatial resolution while fMRI and PET offer the reverse. In the case of fMRI and PET, the requirement that the participant be completely still during measurement makes food sampling impractical. A further constraint of neurophysiological measures of emotion is that they are only able to assess overall activity in isolated brain regions whereas emotional responses are more likely to involve complex brain circuits (Mauss & Robinson, 2009). These limitations make neurophysiological measures impractical tools for consumer research.

The autonomic nervous system (ANS) measures commonly assessed in consumer research are heart rate, heart rate variability, respiratory rate, blood pressure, skin conductance response, and skin temperature (Kreibig, 2010). Activation of the ANS has been investigated in response to odours (Bensafi et al., 2002; Chrea et al., 2009; He, Boesveldt, de Graaf, & de Wijk, 2014), breakfast beverages (de Wijk, He, Mensink, Verhoeven, & de Graaf, 2014) and liked and disliked foods (de Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012). In general, the studies conclude that ANS measures are able to differentiate products by liking and that the temporal development of ANS responses support sequential appraisal emotion theories. The major criticism of ANS activation as a measure of emotion is its lack of reliable emotion-specific differentiation (Cacioppo, Berntson, Klein, & Poehlmann, 1997). Cacioppo, Berntson, Larsen, Poehlmann, and Ito (2000) suggest that ANS measures might be better suited to assessing arousal or approach/avoidance motivations. They also caution that autonomic measures are sensitive to task-specific demands such as cognitive effort, coping mechanisms and physical exertion.

Behavioural methods involve the indirect measurement of physiological changes, such as through video recordings and photographs of facial and bodily states and through computer analysis of the movement of facial landmarks during facial expressions. Other behavioural emotion responses such as vocal characteristics and bodily postures are less commonly assessed, especially so in consumer emotion research (Mauss & Robinson, 2009). FACS is a system of classification of facial movements by visually analysing changes in the individual muscles of the face (Ekman & Friesen, 1977). The coding of facial movements may be executed by trained coders or by automated computer programs such as FaceReader (Noldus Information Technology, Wageningen, The Netherlands). While FACS has been found to be useful in predicting the valence of affective responses to food stimuli in children (Soussignan & Schaal, 1996; Zeinstra, Koelen, Colindres, Kok, & De Graaf, 2009) and adults (de Wijk et al., 2014; Kostyra et al., 2016; Weiland, Ellgring, & Macht, 2010; Wendin, Allesen-Holm, & Bredie, 2011), human and computer analysis of facial recordings lack the ability to detect minute changes in the activity of facial muscles that do not result in visible changes on the face. It is likely that low intensity emotional experiences will result in facial activity that is not detectable using these methods. An alternative method that is able to detect these low intensity transient changes, Facial EMG, will be elaborated upon in the following section.

1.3.3 Facial Electromyography

Facial EMG is a technique that detects and records summed electrical impulses (motor unit action potentials) produced by facial muscles when they contract. Facial muscle activity is highly correlated with self-report and autonomic measures of emotion (Cacioppo, Petty, Losch, & Kim, 1986; Dimberg, 1988, 1990). By recording the zygomaticus major (ZM) (lifts corners of the mouth during smiling) and the corrugator supercilii (CS) muscles (knits brow during frowning), EMG provides a continuous measure of changes in positive and negative affect. The levator labii superioris (LL) muscles on either side of the nose may also be measured as an indicator of disgust (Vrana, 1993; Wolf et al., 2005). EMG's ability to detect visually imperceptible muscle contractions affords insight into aspects of the emotional response that cannot be measured by FACS or explicit emotion measures. Studies have employed this attribute to successfully investigate implicit bias and prejudice that is not revealed by self-report data (Stewart et al., 2013; Vanman, Paul, Ito, & Miller, 1997; Vanman, Saltz, Nathan, & Warren, 2004).

The high sensitivity of EMG also allows for the investigation of weak affective states such as those generated in response to food stimuli. Facial EMG responses have been found to be closely associated with hedonic ratings of food images, odours and liquids (Armstrong, Hutchinson, Laing, & Jinks, 2007; Chrea et al., 2009; Horio, 2003; Hu, Luo, & Hui, 2000; Hu et al., 1999; Jäncke & Kaufmann, 1994). Li (2017) measured EMG and hedonic responses to pleasant, unpleasant and neutral food images and to solutions of quinine, sucrose and water. She found that while ZM activity did not reliably predict liked stimuli, increased CS and LL activity was predictive of disliked images and liquids. In general, measurements of facial behaviour are better at distinguishing between disliked products than between liked products (Danner, Sidorkina, Joechl, & Duerrschmid, 2014; Horio, 2003; Pichon et al., 2015; Zeinstra et al., 2009). This might be explained by the social-communicative function of smiling. In the above studies, participants sampled food stimuli in isolation and as such, may have been less inclined to communicate their positive affect in response to pleasant stimuli. From two studies designed to test the reliability of facial EMG as an emotion measure, Hess et al. (2017) conclude that facial expressions are heavily influenced by contextual factors unrelated to the affective stimuli, but that their effects remain stable over time. This underlines the importance of determining the contributing impact of each of these factors to better understand the relationship between facial expression and affect.

The limitations of facial EMG as an implicit measurement tool include its high cost relative to questionnaires and its low ecological validity due to the presence of electrodes on participants' faces. It should be noted, however, that the electrodes are light and comfortable and participants generally habituate to the sensation within a few minutes of placement.

In chapters 3 and 4, we set out to investigate the how social context affects the relationship between facial responses and food stimuli. We expected to see greater hedonic discriminability by ZM activity as the sociality of the consumption situation increases. The experiments involving facial EMG operated under the guidelines for human electromyographic research as set out by Fridlund and Cacioppo (1986) and reported data according to the standards established by Merletti and Di Torino (1999).

In summary, both explicit and implicit emotion measurement tools report on different but equally important aspects of the emotion response. Explicit tools are convenient but subject to methodological and theoretical limitations. Implicit tools have the ability to measure dynamic emotion processes and do not require conscious attention but the use of scientific equipment may be costly and may interfere with normal consumption behaviour.

1.4 Conclusions

The overarching objective of this research project is to explore the influence of social presence on emotional responses to food. It has been established that social context effects on emotion exist for visual and auditory stimuli. However, its generalisability to food stimuli is less clear. The thesis will investigate this effect using the EsSense25 emotion lexicon and facial EMG as measures of the subjective and the motor-expressive components of the emotion response respectively. In doing so, it also contributes to the literature on implicit emotion measurement in the field of consumer and sensory science.

2 The influence of timing, location and social setting on hedonic and emotional evaluations of past eating experiences

The following article was accepted for publication by *British Food Journal* in February 2020. The version shown is the accepted manuscript, with minor formatting changes for consistency with the rest of this thesis. References for this article are included within the consolidated reference list in section 8. Supplementary materials for this article are included in Appendix A (section 9).

2.1 Abstract

Purpose

Our hedonic and emotional evaluations of the foods we encounter in daily life are predictive of whether we will choose to consume these foods in the future. Given the context-dependent nature of these evaluations and the rise in studies set in naturalistic and ecologically valid consumption settings, it is crucial that we examine the impact of contextual variables on our current consumer emotion measurement methods.

Design/methodology/approach

Three important factors that influence meal-evoked emotion – meal time, location and social setting – were explored via online survey of 866 English-speaking adults from all over the world. Respondents were asked to recall three meals they had consumed in the past week and report on their subjective liking and emotional associations. Subjective liking was measured with a labelled affective magnitude scale and emotion was measured using EsSense25.

Findings

Dinner meals, meals eaten at the home of a family member or friend, and meals eaten with one's spouse or partner were rated highest in subjective liking. Meals eaten at work or alone were associated with the lowest intensities of positive emotion.

Originality/value

The majority of investigations into meal context and emotion have measured consumers' emotional associations in the moment and in the laboratory. The present study characterises the influence of contextual variables on the emotional associations of past eating experiences in naturalistic settings.

2.2 Introduction

Our hedonic and emotional evaluations of the foods we encounter in daily life are predictive of whether we will choose to consume these foods in the future. These responses are complex and are influenced not only by the immediate sensory properties of the food, but also by external factors (e.g. the physical environment, the time of day) and internal factors (e.g. memories of past experiences with the same food, our physical, emotional and mental state). In order to better understand how emotions direct subsequent food choice and behaviour, it is important to examine how they are influenced by contextual factors. The growing interest in emotion measurement within the field of consumer and sensory science has been driven by the findings that consumers' emotional responses to food are better at predicting food choice and better at discriminating between similar food products than sensory or liking evaluations alone (Gutjar, Dalenberg, et al., 2015; Gutjar, de Graaf, et al., 2015; King & Meiselman, 2010; Ng, Chaya, & Hort, 2013). The current literature on consumer emotion has generally been centered on measuring emotion in the moment and in the laboratory, resulting in a relative scarcity of research into the emotional associations we retain of past eating experiences in more naturalistic settings. However, studies have highlighted the role food memories play in directing future food choice and behavior. For example, a 2016 study found that simply asking women to recall their lunch from earlier in the day, resulted in them eating less cookies in an ensuing cookie taste test than participants asked to recall a non-food activity (Vartanian, Chen, Reily, & Castel, 2016). Other studies have demonstrated how being primed with positively-valenced memories of a food result in greater subsequent food intake (Robinson, Blissett, & Higgs, 2011, 2012), and how priming with negative food memories result in greater negative emotional associations towards subsequent food stimuli (Piqueras-Fiszman & Jaeger, 2016).

In order to better understand how past eating experiences influence subsequent food choice and food-related behaviour, it is essential to identify the factors contributing to positive and negative emotional evaluations. Bisogni et al. (2007) situate emotions amongst seven other interconnected context dimensions that together make up each unique consumption experience; the food and drink consumed, timing, location, social setting, concurrent activities, recurrence, and physical state in relation to a meal all appear to have marked effects on the type and intensity of emotions reported. For example, food products receive more positive hedonic ratings when sampled at home than when sampled at a laboratory (Boutrolle, Delarue, Arranz, Rogeaux, & Köster, 2007) and the same meal is rated higher in acceptability when served in a 4-star restaurant compared to an elderly rest home (Edwards, Meiselman, Edwards, & Lesher, 2003). In studies exploring the influence of social setting on emotion, it has been reported that dining with a spouse or partner is associated with increased positive emotional associations (Piqueras-Fiszman & Jaeger, 2015b, 2015c) and dining alone is associated with higher negative emotions both pre- and post-meal (Edwards, Hartwell, & Brown, 2013). The most widely used consumer emotion measurement tool at the time of writing is the EsSense Profile (King & Meiselman, 2010). The EsSense Profile was developed by sourcing emotion terms from existing mood questionnaires, POMS (McNair et al., 1981) and MAACL-R (Lubin et al., 1986), and from internet surveys in which respondents were asked to describe how they felt when they consumed their favourite and least favourite foods. The final 39 terms in EsSense Profile were then selected based on frequency of use and consumer feedback on appropriateness to food product testing. In situations where there are time restrictions, or a large number of samples are being evaluated, EsSense25 (Nestrud et al., 2016), a shorter version of the EsSense Profile, might be more appropriate.

To date, there has been a lack of research inquiring into the factors contributing to positive and negative memories of past eating experiences in ecologically valid settings. Furthermore, in order to draw accurate conclusions from consumer emotion measurement tools such as EsSense Profile and EsSense25, it is vital that we quantify the effects of contextual variables on reported food-evoked emotion. The purpose of the present study was to explore how differences in the timing, location, and social setting of past eating occasions are reflected in hedonic and emotional evaluations.

2.3 Methods

2.3.1 Participants

The study used a convenience sampling method. 867 respondents completed the survey between October 2018 and March 2019, of which 43% were recruited from advertisements on Facebook groups and University student forums. The remainder were recruited from Prolific, an online crowdsourcing platform to connect academic researchers with research participants. Prolific participants were compensated £1 upon survey completion. The sample characteristics are shown in Table 1.

Table 1

Participant demographics

Variable	N (%)
Gender	
Male	356 (41.1)
Female	498 (57.5)
Other/Not stated	12 (1.4)
Age	
18-24	304 (35.1)
25-34	329 (38.0)
35-44	130 (15.0)
45-54	64 (7.4)
55-64	21 (2.4)
65 +	12 (1.4)
Other/Not stated	6 (0.7)
Geographical region	
North America	320 (37.0)
Oceania	313 (36.1)
Europe	166 (19.2)
Asia	42 (4.8)
South America	15 (1.7)
Middle east/Africa	5 (0.6)
Other/Not stated	5 (0.6)

2.3.2 Meal recall

After providing demographic information, respondents were asked to recall three meals they had eaten in the past week. They were asked to think of a variety of meals (e.g. some breakfast, some lunch, some dinner; some at home, some at a dining establishment; some alone, some with others etc.). Respondents were given a free response format text box to describe their recalled meals in as many or as few words as they liked.

2.3.3 Meal time, location and social setting

Respondents were then asked to indicate the meal time, location and social setting of each the meals. There were four response options for meal time – breakfast, brunch, lunch and dinner; seven options for location – at home, at the home of a family member or friend, at work/school/university, at a dining establishment (e.g. restaurant, café, food court), outdoors, in the car, and other (open-ended); and six options for social setting – alone, with spouse or partner, with family member or friend, with family members or friend group, with an acquaintance or someone you just met, and other (open-ended).

2.3.4 Subjective liking

For each meal, respondents were asked to indicate their liking on a labelled affective magnitude scale (LAM) (Schutz & Cardello, 2001). The LAM is a vertical line scale for the assessment of food liking/disliking. It has 11 semantic anchors ranging from "greatest imaginable dislike" at the bottom, to "greatest imaginable like" at the top, with "neither like nor dislike" in the middle.

2.3.5 Consumption emotions

After indicating the context and subjective liking for three meals, respondents were asked to rate the emotions they felt during each meal using the EsSense25 emotion lexicon (Nestrud et al., 2016). A rate-all-that-apply response format was used where respondents selected a number from 0-4 to indicate how strongly they felt each emotion. 0 being not at all, 1 – slightly, 2 – moderately, 3 – very, and 4 – extremely.

2.3.6 Procedure

The survey was custom programmed in HTML and jQueryMobile and hosted on the University's server. It was optimized for responding on both desktop computers and mobile devices. Upon clicking on the survey link, participants were taken to the introduction page, which outlined the survey instructions, participants' rights and researcher contacts. Participants provided informed consent by clicking on the button to start the survey.

On completion, participants were shown a brief summary of all the survey responses thus far. The summary included the proportion of meals in each meal category, location, and social setting, and the top five highest rated emotion words. Only complete responses were collected. The data from 14 participants were excluded because their completion time was over 30 minutes (the survey was designed to be completed in 5 to 10 minutes), suggesting that they may not have been focused on the task. For the remainder of the submissions (853 respondents), the average time taken to complete the survey was 6 minutes and 28 seconds.

2.3.7 Statistical analyses

The data was visually inspected for low-effort responses and one entry was discarded. Open-ended responses for location and social setting were assigned to the existing category that best fitted the response.

The relationship between subjective liking and meal time, location, social setting, age and gender were evaluated using an ANOVA for each predictor. For these analyses, an alpha level of 0.05 was used as the threshold for statistical significance. The relationship between each of the EsSense25 emotion terms and meal time, location, social setting, age, and gender was evaluated using proportional odds logistic regression models with the emotion term as the independent variable and the other variables as predictors. The inference criteria for these analyses was a Bonferroni corrected alpha level of 0.002. All statistical analyses and modelling were conducted in R (R Core Team, 2017).

2.4 Results and discussion

2.4.1 Response characteristics

The largest proportion of recalled meals were dinner meals, meals eaten alone, and meals eaten at home (see Table 2). Meals eaten outdoors, in the car, in other locations (typical responses were hotels, hospitals or events), or with an acquaintance were excluded from subsequent analyses as they comprised less than 2% of total responses in each category. The final number of meals analysed was 2432 meals.

Table 2

Number and proportion of survey responses by Meal, Location and Social setting

Category	N (%)
Meal type	
Breakfast	638 (25.0)
Brunch	84 (3.3)
Lunch	800 (31.3)
Dinner	1034 (40.5)
Location	
At home	1519 (59.4)
At a dining establishment	447 (17.5)
At work/school/university	314 (12.3)
At the home of a family member or friend	180 (7.0)
In the car	52 (2.0)
Outdoors	34 (1.3)
Other	10 (0.4)
Social setting	
Alone	1014 (39.7)
With family members or friend group	651 (25.5)
With spouse/partner	477 (18.7)
With family member or friend	383 (15.0)
With an acquaintance or someone you just met	31 (1.2)

Overall, the most strongly felt emotions were of positive valence – satisfied, good, happy, pleasant and calm. And the least strongly felt emotions were of negative valence – disgusted, aggressive, wild, guilty and worried. This pattern of response is consistent with previous research outlining the hedonic asymmetry of emotions related to food consumption (Desmet & Schifferstein, 2008; King & Meiselman, 2010; Laros & Steenkamp, 2005; Schifferstein & Desmet, 2010). In everyday life, individuals only seek out meal experiences that they expect will have a positive emotional impact.

2.4.2 Gender differences

Overall LAM did not differ between men and women (M_{Diff} = -0.53, t(806) = 0.84, p = 0.40, d = 0.06). Men reported feeling more active, adventurous, aggressive, bored, nostalgic, disgusted, free, tame, wild and interested than women (throughout the results and discussion section, please refer to tables 3 and 4 in Appendix A for all model estimates of odds ratios for emotion terms). Women only rated the emotions enthusiastic and warm more intensely than men, although these differences were not significant at the Bonferonni corrected alpha level (α = 0.002).

In the general emotion literature, there is evidence for gender differences in emotional expression but not for emotional experience (Fischer, Rodriguez Mosquera, Van Vianen, & Manstead, 2004; Kring & Gordon, 1998; Petersen & Hyde, 2010). Women are more emotionally expressive, especially with negative emotion, but both genders typically report experiencing similar intensity of emotion. At first glance, it may seem incongruent that our results show men reporting greater emotion intensity across several positive and negative emotion terms. However, in the literature on food-evoked emotion, it is a common finding (Hartwell, Edwards, & Brown, 2013; McNamara, Hay, Katsikitis, & Chur-Hansen, 2008; Piqueras-Fiszman & Jaeger, 2015b). This could suggest that men tend to recall meals that are more emotionally charged, or that meals are a stronger elicitor of emotion for men than they are for women. This result should be investigated with a confirmatory study.

2.4.3 Age differences

Overall LAM ratings differed between age groups ($F(3, 848) = 4.41$, $p = 0.004$, $\eta^2 = 0.015$). Post hoc comparisons using Tukey HSD tests indicated that compared to respondents in the 18 – 24 age group, respondents in the 25 – 34 (M_{Diff}= 2.27, 95% CI [0.40, 4.14], $p = 0.01$) and 45+ (M_{Diff}= 3.05, 95% CI [0.29, 5.80], $p = 0.02$) age groups rated their meals higher in subjective liking.

18 to 24 year olds reported feeling less tame than all older age groups, more adventurous than 25 to 34 year olds, and more joyful, pleasant, satisfied and wild than 35 to 44 year olds. Respondents aged 45 and above reported feeling less bored than all younger age groups, less guilty than 18 to 24 and 25 to 34 year olds, and less worried than 18 to 24 year olds.

Our finding that older adults felt less guilty, bored and worried about their meals aligns with a study on chocolate- and gingerbread-evoked emotion (den Uijl, Jager, de Graaf, Meiselman, & Kremer, 2016) and a study on wine-evoked emotion (Mora, Urdaneta, & Chaya, 2018) that both employed EsSense25 as an emotion measurement tool. The above studies found that even within these narrowly defined food categories, older adults report less high arousal and less negative emotions compared to younger age groups. Our results, along with the studies mentioned above, suggest that there are consistent age-related differences in food-evoked emotion.

2.4.4 Meal time

Subjective liking differed between meals ($F(3, 2428) = 28.64$, $p < 0.001$, $\eta^2 = 0.03$). Breakfast was rated lower in liking compared to Brunch (M_{Diff}= -6.05, 95% CI [-10.12, -1.98], $p < 0.001$), Lunch (M_{Diff}= -1.94, 95% CI [-3.80, -0.08], $p = 0.04$) and Dinner (M_{Diff}= -5.85, 95% CI [-7.60, -

4.10], $p < 0.001$). Brunch (M_{Diff}= 4.11, 95% CI [0.08, 8.14], $p = 0.04$) and Dinner (M_{Diff}= 3.91, 95% CI [2.26, 5.56], $p < 0.001$) were rated higher in liking compared to Lunch.

Brunch did not differ in reported emotions compared to any of the other meal categories. Dinner was rated less calm and less good compared to lunch. Dinner was rated less active, calm, secure, good, and goodnatured, and more guilty compared to breakfast, and less active, calm, and good compared to lunch.

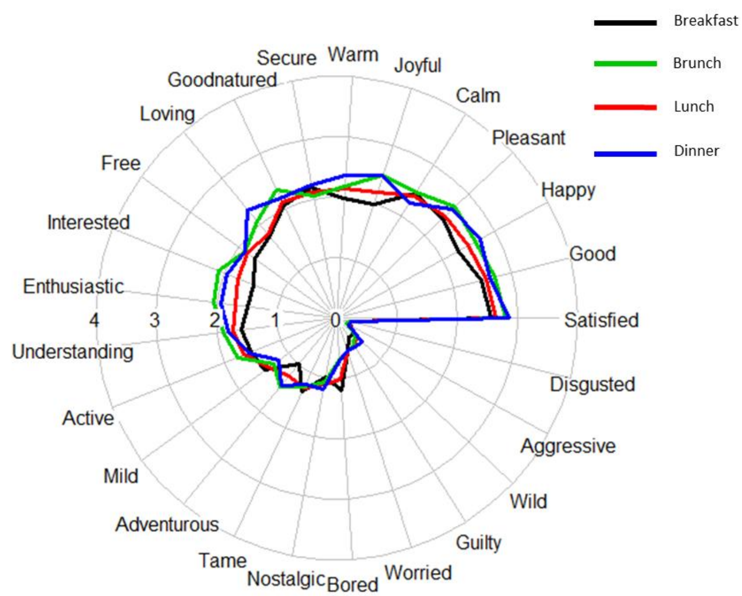


Figure 1. Comparison of mean emotional responses on EsSense25 by meal. Ratings range from 0 - "not at all” to 4 - "extremely".

Overall, the emotional associations for the four meals were comparable (Figure 1). This was also the finding in a mealtime-related emotions survey on older adults using EsSense25 (den Uijl, Jager, de Graaf, Waddell, & Kremer, 2014). This suggests that the timing of a meal may not play as large a role as other contextual variables in determining meal emotions. An explanation of the result that ratings of some positive emotion terms were lower for dinner meals compared to breakfast, while ratings of guilty was higher could be because 19% of dinners were eaten at a dining establishment compared to just 6% of breakfast meals in our sample. Given that we tend to be more conservative and routine with our breakfast food choices (Khare & Inman, 2006), the greater variety of our dinner meals may give rise to more positive and negative emotional experiences.

2.4.5 Location

Subjective liking differed between locations ($F(3, 2428) = 26.79$, $p < 0.001$, $\eta^2 = 0.03$). Meals eaten at work were rated lower in liking compared to meals eaten at home (M_{Diff}= -5.79, 95% CI [-7.97, -3.62], $p < 0.001$), at a dining establishment (M_{Diff}= -8.11, 95% CI [-10.68, -5.54], $p < 0.001$) or at the home of a family member or friend (M_{Diff}= -9.07, 95% CI [-12.31, -5.84], $p < 0.001$). Meals eaten at home were rated lower in liking compared to meals eaten at a dining establishment (M_{Diff}= -2.32, 95% CI [-4.16, -0.48], $p = 0.007$) or at the home of a family member or friend (M_{Diff}= -3.28, 95% CI [-5.97, -0.59], $p = 0.01$).

While work meals may differ categorically from meals eaten elsewhere, it has been demonstrated that even the same food products and meals consumed in institutional settings receive lower acceptability ratings compared to when they are consumed in a restaurant or at home (Boutrolle, Arranz, Rogeaux, & Delarue, 2005; Boutrolle et al., 2007; Edwards et al., 2003; Meiselman, 2000). Our results provide evidence that this might be the case with memories of past meals and for dining locations as well.

Compared to eating at home, eating at a dining establishment was more active, adventurous, guilty, wild, worried and interested, and less bored and calm. Eating at home was also rated less wild and less loving than eating at the home of a family member or friend. Eating at the home of a family member or friend was more loving and warm, and less guilty than eating at a dining establishment. Meals eaten at work were less loving, nostalgic, calm, secure and free compared to eating at home, less joyful, loving, nostalgic, pleasant, secure, free, good, warm and happy compared to meals eaten at the home of a family member or friend, and less joyful, adventurous, loving, pleasant, enthusiastic, free, guilty, happy and interested and more bored than meals eaten at a dining establishment.

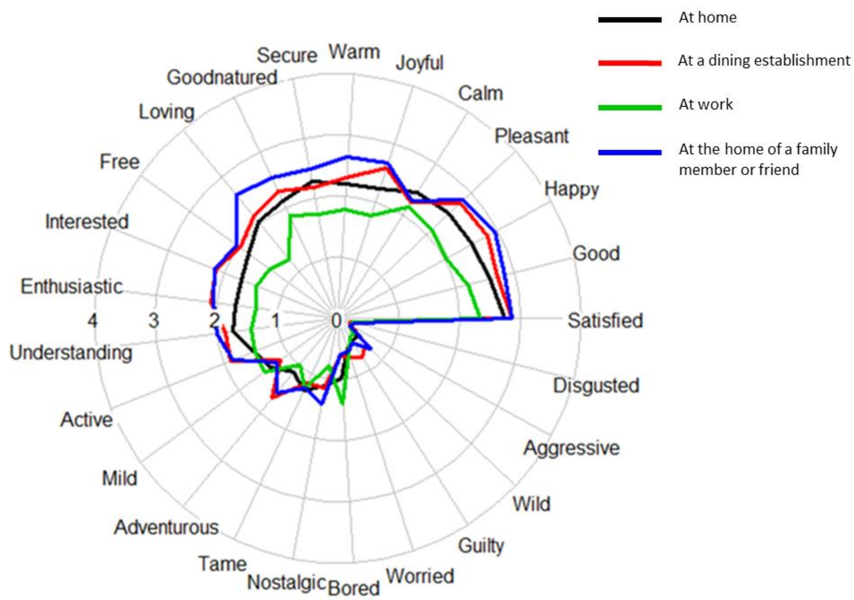


Figure 2. Comparison of mean emotional responses on EsSense25 by location. Ratings range from 0 - “not at all” to 4 - “extremely”.

Meals eaten at the home of a family member or friend and meals eaten at a dining establishment were very similar in the highly rated positive emotions of satisfied, good, happy, pleasant and joyful, but were differentiated by a second group of increased positive emotions – warm, secure, goodnatured and loving. This second group of positive emotions appear to be socially-oriented, in contrast with the first set which reflect internal states. These results are in line with the finding that menu descriptions with allusions to home and family (e.g. Grandma’s Home-made Grilled Chicken or Aunt Annie’s Apple Pie) are associated with increased sales (Guéguen & Jacob, 2012).

Meals eaten at work evoked the lowest intensity of positive emotion and the highest ratings for bored compared to all other locations (Figure 2). Our results highlight the importance of taking location into consideration when interpreting data from emotion questionnaires. For example, the emotions evoked during a home-use product test, may not be predictive of consumer liking or willingness to purchase the same product in a supermarket or restaurant.

2.4.6 Social setting

Subjective liking differed between social settings ($F(3, 2428) = 56.29$, $p < 0.001$, $\eta^2 = 0.07$). Compared to meals eaten alone, meals eaten with a family member or friend (M_{Diff}= 7.12, 95% CI [5.08, 9.17], $p < 0.001$), family members or a friend group (M_{Diff}= 5.91, 95% CI [4.20, 7.62], $p < 0.001$) or with a spouse/partner (M_{Diff}= 7.98, 95% CI [6.08, 9.88], $p < 0.001$) were rated higher in liking. Meals eaten with a spouse or partner were rated marginally higher in liking than meals eaten with family members or a friend group (M_{Diff}= 2.07, 95% CI [0.01, 4.12], $p = 0.049$).

Eating in the company of others was associated with higher ratings of active, joyful, loving, pleasant, enthusiastic, secure, good, understanding, goodnatured, warm, happy and interested emotions and lower ratings of bored. Eating with one's spouse or partner specifically was associated with higher loving ratings compared to all other social settings. Our findings reinforce the fact that social meals are a significant source of positive emotions.

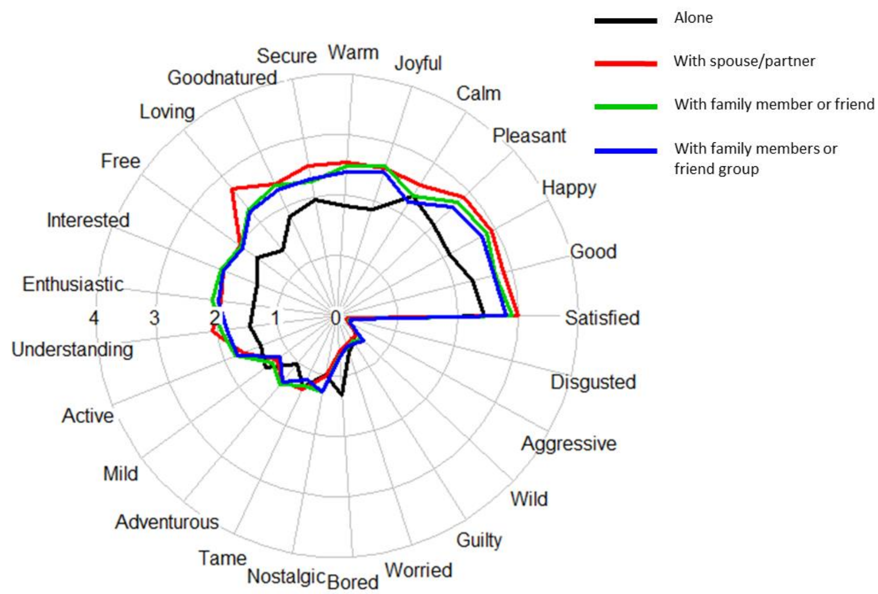


Figure 3. Comparison of mean emotional responses on EsSense25 by social setting. Ratings range from 0 - "not at all" to 4 - "extremely".

As illustrated in figure 3, meals eaten alone were associated with lower ratings of positive feelings overall, except for calm. The feeling of calmness could possibly be more related to other consumption dimensions not captured by this survey such as physical state, concurrent activities and recurrence or familiarity. These results underline the value of social eating and the need to consider the social environment in consumer testing.

2.4.7 Relationship between emotion and subjective liking

Increased subjective liking ratings were associated with higher ratings for active, joyful, adventurous, loving, nostalgic, calm, pleasant, satisfied, enthusiastic, secure, free, good, understanding, goodnatured, warm, wild, happy, worried and interested. Increased subjective liking ratings were associated with lower ratings for aggressive, mild, bored, disgusted, guilty and worried. The only emotion term that did not have a relationship with liking was tame.

This finding that food acceptability is associated with increased positive emotion and decreased negative emotion has previously been observed (Cardello et al., 2012; Gutjar, Dalenberg, et al., 2015; Gutjar, de Graaf, et al., 2015), however, this is the first time it has been demonstrated with memories of past meals, suggesting that these associations are stable even after some time has passed.

2.5 Conclusion

This study investigated the influence of meal time, location and social setting on emotional associations of recalled meals. It was found that social meals amplified positive emotion relative to solitary meals, work meals diminished positive emotion relative to meals eaten elsewhere and that meal timing did not have as much of an influence on emotional associations in comparison to meal location and sociality. However, further research is needed with a more diverse and representative sample before we can generalise these findings to the wider population. Future research should investigate the influence of recurrence, physical state and concurrent/preparatory activities on meal emotions and attempt to capture emotional associations closer in temporal proximity to the consumption event. The current findings contribute to the literature on context and emotion within the field of consumer and sensory science, highlighting the importance of considering timing, location and social setting in consumer product test design, especially when measuring emotion. These findings may also inform restaurant marketing campaigns, personal meal behaviour, and interventions for diet change in clinical populations.

3 An unfamiliar social presence reduces facial disgust responses to food stimuli

The following article was published by *Food Research International* in December 2019. The version shown is the accepted manuscript, with minor formatting changes for consistency with the rest of this thesis. References for this article are included within the consolidated reference list in section 8. Supplementary materials for this article are included in Appendix B (section 10). The final publication is available at Elsevier via the following citation.

Nath, E. C., Cannon, P. R., & Philipp, M. C. (2019). An unfamiliar social presence reduces facial disgust responses to food stimuli. Food Research International, 126, 108662.

This research was also presented in a poster session at The International Society for Research on Emotion July 2019 Conference in Amsterdam. The poster is available online at the following link: https://osf.io/wuqg8.

3.1 Abstract

Consumers' emotional responses complement sensory and hedonic ratings in the prediction of food choice and consumption behaviour. The challenge with the measurement of consumption emotions is that emotions are highly context dependent. For emotion evaluations to bring greater insight to food research and development, it is essential that the influence of contextual variables on emotion are quantified. The present study contributes to the discussion with an investigation of the effect of an unfamiliar social presence on affective facial responses to visual food stimuli. Seventy participants (52 female and 18 male) viewed food images of varying acceptability either alone, or in the presence of the researcher. Subjective liking ratings were measured using a labelled affective magnitude scale, and facial muscle activity from zygomaticus major (contracted during smiling), corrugator supercilii (contracted during frowning) and levator labii superioris (contracted during nose wrinkling) were measured with an EMG recording system. Controlling for individual differences in facial expressivity and food

image acceptability using linear mixed models, it was found that social context did not predict smiling or frowning muscle activity. Social context did predict the intensity of muscle activity indicative of a disgust response, with participants in the observed condition exhibiting less levator activity than participants in the alone condition. Regardless of social context, each muscle was found to have a relationship with subjective liking, with the direction of effects as expected. The results indicate that emotional stimuli and social context both influence food-evoked facial expression and provides support for the utility of facial EMG in measuring food-evoked emotion.

3.2 Introduction

The measurement of consumption emotions has been a recent trend in the field of consumer and sensory science. Consumers' emotional responses to food have been found to be better at predicting food choice and better at discriminating between similar food products than sensory or liking evaluations (Gutjar, Dalenberg, et al., 2015; Gutjar, de Graaf, et al., 2015; King, Meiselman, & Carr, 2010; Ng et al., 2013). The main challenge with the measurement of consumption emotions is that they are highly context-dependant. Bisogni et al. (2007) situate them amongst seven other interconnected context dimensions that together make up each unique consumption experience. The timing, location, social setting, concurrent activities, and one's thoughts and physical state in relation to a meal all appear to have marked effects on the type and intensity of emotions reported (Bisogni et al., 2007). One variable that deserves greater research attention is social context.

Social context research in consumer and sensory science has generally embedded the sociality of the consumption situation within in the wider consumption context (Danner et al., 2016; Delarue, Brasset, Jarrot, & Abiven, 2019; Di Monaco, Giacalone, Pepe, Masi, & Cavella, 2014). For example, Nijman et al. (2019), compared consumers' hedonic and emotional evaluations to beer tasted alone in a sensory booth or at a student bar where the social setting was not controlled. Similarly, many studies have characterised the differences between central location tests, where participants are usually alone, and home-use tests, where others may or may not be present (Boutrolle & Delarue, 2009; Boutrolle et al., 2007; Delarue & Boutrolle, 2010). As such, it is impossible to disentangle the effect of social context from other factors such as the physical environment, location and ambience on consumer evaluations.

When social context has been investigated to the exclusion of other confounding factors, the focus has largely been on the influence of the other person's gaze direction (Soussignan, Schaal, Boulanger, Garcia, & Jiang, 2015; Soussignan, Schaal, & Jiang, 2019; Wang, Wedel, Huang, & Liu, 2018), facial expressions (Barthomeuf, Rousset, & Droit-Volet, 2010; Kulesza et al., 2017; Rizzato et al., 2016), appraisals (Regan et al., 2014), or social norms (Jensen & Lieberoth, 2019; Prati, Pietrantoni, & Zani, 2012; Zandstra, Carvalho, & Van Herpen, 2017). Few studies have examined the direct effect of the physical presence of another person on hedonic and emotional evaluations. This is highly relevant to consumer research because the presence or absence of the researcher in typical product evaluation settings may have unexpected effects on consumer responses.

The social context of a meal exerts a robust influence on eating behaviour – people eat more and take longer to eat when dining with others compared to when they dine alone (Bell & Pliner, 2003; De Castro, 1990, 1995; Herman, 2015; Hetherington et al., 2006; Sommer & Steele, 1997). Social context also impacts food choice in the short term (McFerran, Dahl, Fitzsimons, & Morales, 2009) and eating habits in the long term (Badaly, 2013; Christakis & Fowler, 2007; Pachucki, Jacques, & Christakis, 2011; Paxton et al., 1999; Salvy et al., 2012). Given the wide-ranging effects social context has on consumption behaviour, it is not surprising that it also has an influence on consumption emotions. In a small qualitative study at a student cafeteria, university students reported that eating lunch with others enhanced the emotional experience of the meal, especially feelings of satisfaction, contentment and relaxation (Brown et al., 2013). Similarly, in their research into memorable meals, Piqueras-Fiszman and Jaeger (2015b, 2015c) found that dining with a spouse or partner was associated with increased positive emotional associations. Additionally, they reported that participants rated the company during a meal as the most important aspect contributing to a memorable meal, even more so than the actual food and drink consumed.

3.2.1 Consumer emotion measurement

As in the studies discussed above, consumption emotions are generally investigated using self-report measures such as questionnaires, interviews and focus groups, that assess the conscious, explicit level of the emotion process (Kaneko, Toet, Brouwer, Kallen, & Van Erp, 2018). A systematic review by Lagast, Gellynck, Schouteten, De Herdt, and De Steur (2017) highlighted the preponderance of explicit emotion measurement methods in consumer and sensory science with 80% of studies reviewed using only explicit measures of emotion. Widely used emotion lexicons such as EsSense Profile (King & Meiselman, 2010) are convenient and cost-effective to administer, but only reflect a retrospective and static impression of the dynamic emotion process. The insights gleaned by these measures are also limited to the subjective experience component of emotion. Component theories of emotion postulate that in addition to subjective experience, there are four other fundamental components that constitute the emotion process – cognitive, neurophysiological, motivational and expressive (Scherer, 2005). These components are not readily available to conscious awareness and thus go undetected by explicit measurement methods. To capture the unconscious aspects of the emotion process, implicit methods such as functional neuroimaging, skin conductance measurement, facial action coding system (FACS) and facial electromyography (EMG) are employed instead. Facial muscle activity in the zygomaticus, corrugator and levator regions have been shown to reliably distinguish between pleasant and unpleasant visual, olfactory and taste stimuli (Armstrong et al., 2007; Cannon, Li, & Grigor, 2017; Hoefling et al., 2009; Hu et al., 2000; Hu et al., 1999; Soussignan, Schaal, Rigaud, Royet, & Jiang, 2011; Wolf et al., 2005) and the advances in automatic facial expression analysis software such as Noldus FaceReader and Microsoft Face API have made facial expression measurement a common staple in consumer researchers' toolboxes. Implicit emotion measurements have proved to be an important complement to explicit measures leading to more accurate predictions of consumer liking and preference and a better understanding of food cravings and attitudes towards food quality and food safety (He, Boesveldt, de Graaf, & de Wijk, 2016; Leitch, Duncan, O'keefe, Rudd, & Gallagher, 2015; Piqueras-Fiszman & Jaeger, 2014; Samant, Chapko, & Seo, 2017; Samant & Seo, 2019; Walsh, Duncan, Bell, O'Keefe, & Gallagher, 2017; Walsh, Duncan, Bell, O'Keefe, & Gallagher, 2017; Yen et al., 2010).

When considering social context effects on emotion, FACS and facial EMG methods are particularly insightful due to the social-communicative function of facial displays. Not only do our facial expressions serve as readouts of our internal state, they also communicate important information about the immediate environment, guide and reward the behaviour of perceivers (Keltner, Sauter, Tracy, & Cowen, 2019). This explains the well-established observation that sportspersons rarely display expressions at the peak of expected emotion intensity (winning or losing) and instead are most expressive when confronted with an audience (Crivelli et al., 2015; Fernández-Dols & Crivelli, 2013; Fernández-Dols & Ruiz-Belda, 1995; Ruiz-Belda et al., 2003).

3.2.2 Social presence and facial expression research in the wider psychological literature

Facial expressions tend to align with reported emotion valence and intensity but are also highly sensitive to the sociality of the situation (Hess et al., 1995; Hess & Hareli, 2015; Philipp et al., 2012). For example, Wagner and Smith (1991) manipulated social context by having female participants view slides with emotional content with a friend or with a stranger. Their facial expressions were covertly filmed and then shown to raters to guess the type of emotional content that had been viewed. Measurements of rater accuracy indicated that women were more expressive in the company of a friend than in the company of a stranger, but this pattern was not uniform across all emotions. Using a similar methodology, Buck et al. (1992) found that compared to viewing emotional stimuli alone, the presence of strangers inhibited facial displays in general, while friends facilitated some expressions and inhibited others. Social context effects are found even with children. Soussignan and Schaal (1996) investigated the facial responses of 5 to 12 year olds who smelled odours either alone or in the presence of an unfamiliar female examiner. Facial expressions communicated unpleasant odour valence better in the alone condition, and pleasant odour valence better in the social presence condition. This suggests that children may suppress negative expression and facilitate positive expression in the presence of an unfamiliar adult. In studies focussing on negative emotional stimuli, results show that people tend to display fewer negative expressions and more positive expressions in the presence of others, regardless of whether the other person was a friend or stranger (Jakobs, Manstead, & Fischer, 2001; Lee & Wagner, 2002). In general, facial expressions are amplified or inhibited by social presence depending on the emotional valence of the stimuli and the relationship between the expresser and their audience.

3.2.3 Social presence and facial expression to food stimuli

With facial expressions to food stimuli, social presence appears to facilitate positive facial displays to liked stimuli (Bredie, Tan, & Wendin, 2014; Horio, 2003; Zeinstra et al., 2009). A study by Jäncke and Kaufmann (1994) measured facial muscle activity in response to pleasant and unpleasant odours inhaled either alone or with the experimenter seated directly in front of the participant. They found that participants who smelled pleasant odours with an audience displayed stronger smiling activity compared to those who smelled the same odours in private.

A study using Noldus FaceReader technology came to similar conclusions (Danner et al., 2014). For participants who were unaware their facial reactions were being filmed, happy expressions did not reflect subjective liking ratings. In contrast, for participants who were aware, happy expressions correlated strongly with liking and afforded superior discrimination between samples. Additionally, a study using virtual avatars as social presence found that presenting avatars with faces of joy concurrently with food images increased participants' subjective liking and zygomaticus (smiling) activity (Soussignan et al., 2015). Regarding negative facial displays to food stimuli, both facilitative (Jäncke & Kaufmann, 1994) and inhibitory (Kraut, 1982) effects of social presence have been found.

The facilitation of positive expression in the presence of others may provide a solution to the most often cited limitation of facial expression methods in consumer research – when eating alone, people reliably display negative facial responses to disliked stimuli but rarely display positive facial responses to liked stimuli (Bredie et al., 2014; Horio, 2003; Juodeikiene et al., 2018; Zeinstra et al., 2009; Zhi, Wan, Zhang, & Li, 2018). Increased sociality may increase positive expression overall, regardless of the valence of the stimuli, or it might increase as a function of subjective liking. If the latter, increasing the sociality of testing environments would be an easy way to expand the utility of these implicit emotion measurement methods.

3.2.4 Aims and hypotheses

The aim of the present study was to investigate the influence of social presence on positive and negative facial displays in response to food images. In consumer and sensory science, the facilitation of facial expression by social context might offer greater insights into food acceptability and food choice. Additionally, characterising the effect of the presence or absence of the researcher on hedonic and emotional evaluations would inform future product testing design. The following hypotheses were preregistered with the Open Science Framework (https://osf.io/4j6nv/register/565fb3678c5e4a66b5582f67).

H1. For all liked images, regardless of content, mean zygomaticus activity will be greater in the observed condition; i.e. social presence amplifies positive expression.

H2. For all disliked images, regardless of content, mean corrugator and mean levator activity will be greater in the alone condition; i.e. social presence inhibits negative expression.

To summarise, consistent with the literature reviewed, we hypothesize that social presence will facilitate facial muscle activity indicative of positive affect toward pleasant food images and inhibit facial muscle activity indicative of negative affect toward unpleasant food images.

3.3 Method

3.3.1 Participants

Seventy participants (52 women, 18 men) aged between 18 and 74 (M = 28.8, SD = 10.0) and primarily of Asian and NZ European descent were recruited via advertisements placed around the university campus and on local community Facebook groups. Advertisements were in English and asked for participants to be 18 years and older. No other exclusion criteria were stipulated. All participants gave written consent and were compensated for their time with a NZ$15 department store or supermarket gift card.

3.3.2 Design

Participants were randomly assigned to one of two experimental conditions – alone or observed. Participants in the alone condition were directed to sit in front of a computer screen in a sound-attenuated testing booth while participants in the observed condition were directed to sit in front of a computer screen beside the experimenter in the main lab. 35 individuals participated in the alone condition and 35 participated in the observed condition.

3.3.3 Stimuli

Thirty food images were selected such that their perceived acceptability would likely be distributed along the entire valence scale (ranging from greatest imaginable like to greatest imaginable dislike). In their study on food images and acceptability conducted in Auckland, New Zealand, Li (2017) found that the local sample rated images of familiar foods such as cake, roast chicken and chocolate highest in acceptability and rated images of unfamiliar foods from foreign cultures such as Balut (Philippines) and Svið (Iceland) lowest in acceptability. The images were presented with PsychoPy (Peirce, 2007) on a 60.5cm Philips monitor with 1920x1080 resolution and a 60Hz frame rate. The timing of trial events was synchronised with the psychophysiological recording software via parallel port. All images used in the present study are licensed for reuse and are included in Appendix A.

3.3.4 Measures

3.3.4.1 Subjective liking ratings

Subjective liking was measured using the labelled affective magnitude scale (LAM), developed by Schutz and Cardello (2001) to measure food liking. The LAM is a vertical, 100-point, line scale with 11 semantic anchors ranging from “greatest imaginable dislike” at 0, to “greatest imaginable like” at 100.

3.3.4.2 Facial Electromyography

Muscle activity from zygomaticus major (contraction lifts corner of mouth during smiling), corrugator supercilii (contraction knits brow during frowning) and levator labii superioris (contraction wrinkles nose during expressions of disgust) (Fridlund & Cacioppo, 1986) on the left side of the face was recorded using a BIOPAC MP150 physiological recording device, three BIOPAC amplifiers, and six 4mm Ag/AgCl reusable surface electrodes (BIOPAC Systems Inc., Goleta, CA). An 8mm ground electrode was attached to the forehead near the hairline.

3.3.5 Procedure

Upon expressing interest in the study, potential participants were emailed a study information sheet describing the experimental procedure. The information sheet explained that the purpose of the study was to investigate facial behaviours in response to food images and as such, participants were blind to the social context manipulation. On arrival at the lab, each participant was asked to sign a consent form and given a NZD$15 gift card. To prepare the skin sites for electrode adhesion, participants were first asked to wash their face with a mild facial cleanser. Then, the skin sites were cleaned with an alcohol swab and abraded with an abrading pad. A small amount of electrode gel was applied to each skin site with a cotton bud and any excess gel was wiped off with a tissue. Once the electrodes were attached, participants in the alone condition were directed to sit in front of a computer screen in a sound-attenuated testing booth while participants in the observed condition were directed to sit in front of a computer screen beside the experimenter in the main lab. The participants' chair was positioned such that their faces were between 60 and 70cm from the monitor. In the observed condition, the experimenter sat silently beside the participant facing the screen and maintained a neutral expression and body language. The seating arrangement was such that direct eye contact between the participant and experimenter was not possible. In both conditions, the experimenter ran a simulation of the experiment and demonstrated response requirements before starting the main experiment. In the main experiment, participants viewed thirty food images presented in a randomised order and rated their liking of each food image on the LAM scale. Each trial consisted of a fixation screen displayed for 5000ms (a white "+" presented in the centre of the screen against a grey background), a food image displayed for 5000ms (a 1024 x 768 pixel image presented in the centre of the screen against a grey background) and a rating screen (the LAM scale in white font against a grey background) displayed until the participant made a response. Participants were required to indicate their liking with a single mouse click on the scale. Following the food images, participants were asked to sample a piece of dark chocolate and a piece of milk chocolate (approximately 3g in weight) and rate their liking on the LAM scale. The chocolate stimuli were included in the experimental procedure to collect pilot data for a subsequent study and will not be discussed in the current report. After participants rated the food images and chocolate samples, maximum facial muscle contractions were recorded with the aid of on-screen prompts to pose a frown, wrinkle the nose and smile. Finally, the experimenter removed the electrodes and debriefed participants, explaining the true aims of the study.

3.3.6 Data processing

The EMG signals were relayed through shielded cable to Biopac amplifiers set to a gain of 5000 with a high pass filter at 1Hz. The signal was digitally recorded at 2000Hz using Acqknowledge 4.2 software. Raw data files (Nath, Cannon and Philipp, 2017) were uploaded regularly during the data collection phase to a Zenodo online depository and are available under the Creative Commons Attribution Share-Alike 4.0 licence. Offline, Butterworth second order filters were applied using the biosignalEMG package (Guerrero & Macias-Diaz, 2018) in R (R Core Team, 2017). The filters consisted of a high pass filter at 20Hz to remove movement artifacts and unstable low frequency muscle activity, a low pass filter at 500Hz to remove noise above the upper limit of muscular electrical potential, and band stop filters every 50Hz to remove mains frequency interference and harmonics. The signal was then rectified and smoothed. Changescores were calculated by first converting each data point to a percentage of the peak maximum contraction for each muscle and then subtracting the mean muscle activity during the last 500ms of the fixation screen. This was then converted to z-scores. Trials were dropped if the fixation muscle activity was over 2 standard deviations from the mean (11.4% of total trials). Multivariate outliers computed using Mahalanobis distance were also excluded from all analyses (2.8% of total trials).

3.3.7 Data analysis

To investigate the effect of social presence on muscle activity, the use of independent samples t-tests was proposed in our preregistration (results are included in Appendix B). However, after inspecting the data, it was decided that due to its clustered nature, linear mixed-effects modelling would be a more appropriate statistical approach. Nonetheless, the results of our proposed t-tests are included in Appendix B. The use of t-tests on clustered data underestimates variability in the data due to correlations within clusters and results in an increased probability of reporting false positives (Galbraith, Daniel, & Vissel, 2010). Linear mixed-effects models would be able to account for individual differences in facial expressivity and rating scale response style between participants as well as the differences between food images as elicitors of liking and affect. Muscle activity for each muscle was considered as dependent variables, LAM rating was considered a continuous fixed effect, and Condition was considered as a categorical fixed effect. Individual participants and individual food images were considered as single-level random effects. A maximum likelihood estimation approach was used throughout to compare models using a chi square test on model likelihood. Confidence intervals for fixed effects were calculated using parametric bootstrapping based on 10,000 simulations of the fitted models. The 2.5% and 97.5% percentiles were extracted to give an estimate of the 95% confidence level for each effect. An alpha level of $\alpha = 0.05$ was used for all analyses and the sample size was determined based on the expected effect size of the between subject manipulation with power at $\beta = .8$.

All statistical analyses and modelling were conducted in R (R Core Team, 2017). Specifically, the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) was used to estimate linear mixed model effects, figures were generated using ggplot2 (Wickham, 2009) and yarr (Phillips, 2017), and tables were generated using stargazer (Hlavac, 2018).

3.4 Results

3.4.1 Preliminary analyses

Maximum contractions for all three muscles did not differ between conditions (all $p>.05$). Fixation muscle activity for zygomaticus major and levator labii superioris did not differ between conditions, but baseline activity for corrugator supercilii was higher in the observed group than in the alone group ($M_{alone} = 1.78$, 95% CI [1.42, 2.13], $M_{observed} = 2.54$, 95% CI [1.96, 3.12]; t(56.2) = -2.28, *p* = 0.03). LAM ratings did not differ between conditions (M_{alone} = 56.41, 95% CI [54.39, 58.43], $M_{observed}$ = 55.76, 95% CI [53.79, 57.73]; t(1757) = 0.45, *p*=0.65).

3.4.2 Facilitation and inhibition of facial muscle activity

To investigate if positive facial muscle activity was facilitated, and negative facial muscle activity inhibited by social presence, three models of increasing complexity were specified for each muscle. The statistical notation and lmer specification for these models are included in Appendix B. Inspecting the intra-class correlation coefficients of the models, it was clear that muscle activity was clustered by participant and by food image albeit to varying degrees (see table in Appendix B). Therefore, within all the models there is a fixed adjustment to the prediction of the intercept for the LAM score based on the participant and item combination with no adjustment to the slopes for the fixed effects. The first model was a null model with participant and food image as random intercepts, allowing for between subjects and between stimuli variation in muscle activation. The second model included LAM ratings as a continuous fixed effect and the third and final model built on the second by including social condition as a categorical fixed effect. LMM coefficient tables are included in Appendix B.

For all three muscles, entering LAM into the model resulted in an improved likelihood, $\chi^2(1)_{zygomaticus}$=6.03, p=0.01, $\chi^2(1)_{corrugator}$=44.72, p<0.001, $\chi^2(1)_{levator}$=28.8, p<0.001. An increase of one standard deviation in LAM resulted in a 0.04 [0.01, 0.06] standard deviation increase in zygomaticus activity, a 0.18 [0.14, 0.22] standard deviation decrease in corrugator activity and a 0.10 [0.01, 0.12] standard deviation decrease in levator activity (see Figure 1). Adding Condition as a predictor did not improve the model likelihood for zygomaticus, $\chi^2(1)_{zygomaticus}$=0.72, p=0.40, or corrugator, $\chi^2(1)_{corrugator}$=0.86, p=0.35, but did for levator, $\chi^2(1)_{levator}$=4.23, p=0.04. Levator activity in the observed condition was estimated to be 0.14 [0.01, 0.26] standard deviations less than levator activity in the alone condition (see Figure 2).

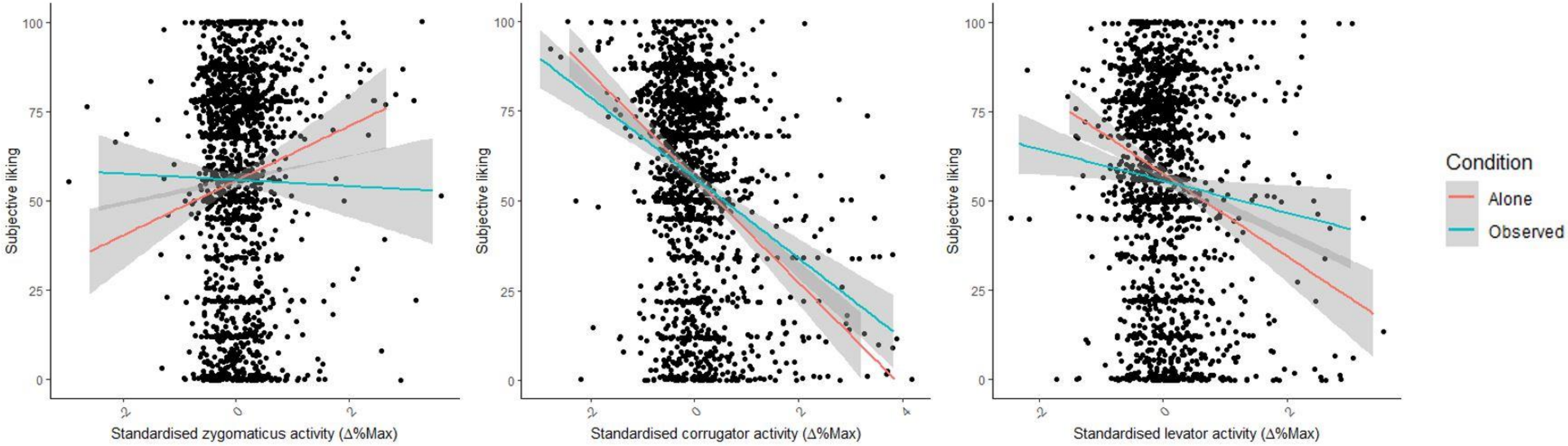


Figure 4. The relationship between subjective liking and standardised muscle activity by social condition. Each data point represents one image viewed by one participant.

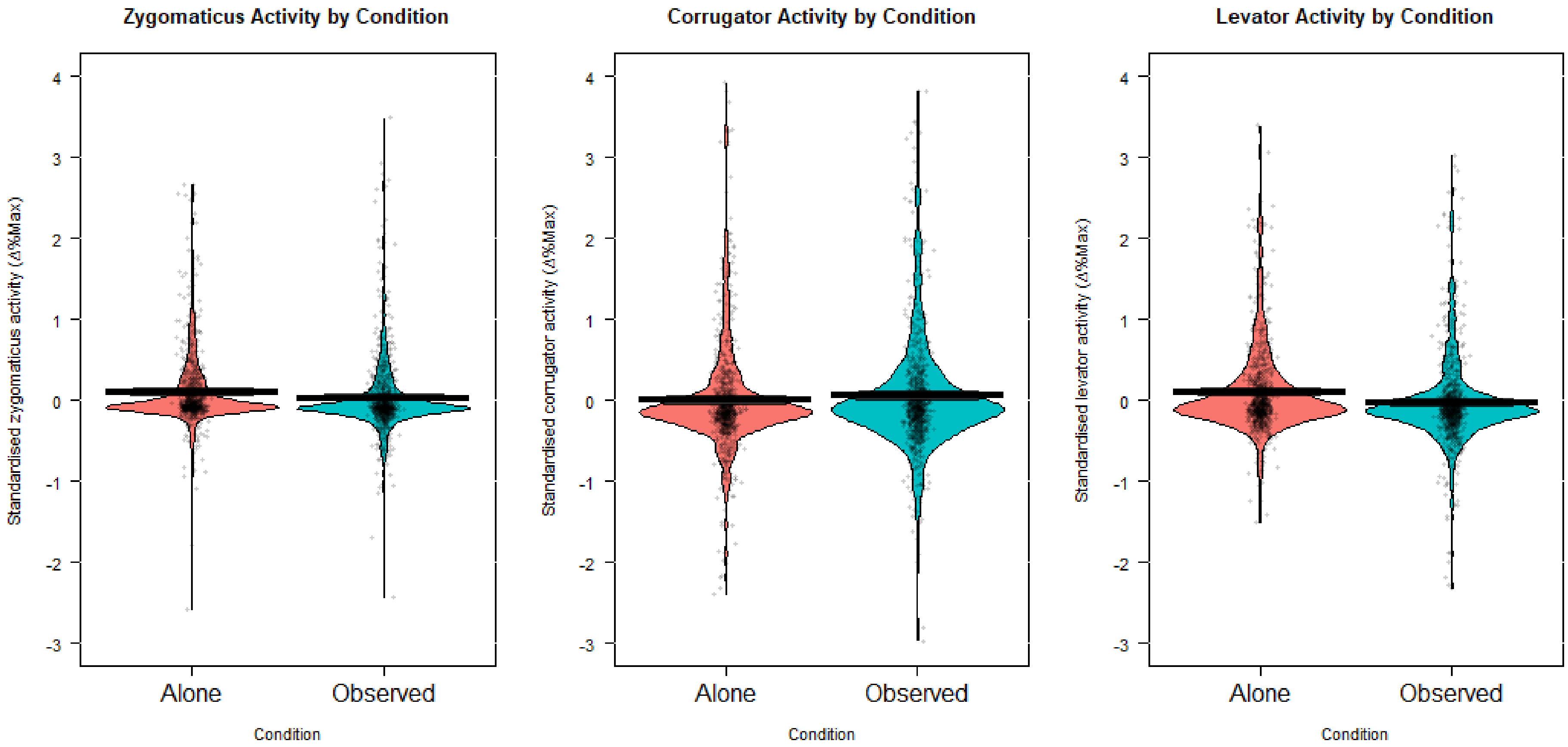


Figure 5. Standardised EMG changescores as a percentage of maximum contractions for zygomaticus major, corrugator supercilii and levator labii superioris activity in each condition. The black lines represent the means and the black bars represent the 95% highest density intervals for the means of each group.

3.5 Discussion

Our results show partial evidence for the influence of social context on food-evoked implicit emotion. We predicted that social presence would amplify positive facial expression (H1). The results did not support this hypothesis. The inclusion of social condition as a predictor in our model did not increase predictability for zygomaticus activity. A possible explanation for this lack of effect for smiling could be due to the presence of the experimenter being that of an audience rather than a co-experiencer. In their research on the social facilitation of emotion, Jakobs, Fischer, and Manstead (1997) distinguish between audience effects and co-action effects. The mere presence of another did not appear to influence subjective emotional responses to emotion-eliciting vignettes, but the presence of a co-experiencing friend did. Jakobs, Manstead, and Fischer (1999) also went on to observe that smiling was increased in face-to-face interactions with friends, but not with strangers. Future research could investigate this difference in food-evoked emotion. The role of the other is also of import in the context of consumption behaviour. Non-eating eating observers suppress food intake (Herman et al., 2003) and the desire to affiliate with the other person has a stronger effect on food intake modelling than mere presence alone (Cruwys et al., 2015). In the present study, participants' individual differences in desire to affiliate with the experimenter and her role as an observer as opposed to co-experiencer may account for the lack of an effect in either direction. Looking at the relationship between subjective liking and zygomaticus activity in Figure 1, social presence appeared to exert an inhibitory effect although this did not reach significance due to large within-group variability. It could be possible that our social context manipulation did not translate to a corresponding difference in the perceived sociality of each condition. Including measures of sociality and desire to affiliate would be useful in future studies of social context.

We also predicted that negative facial muscle activity would be inhibited by social presence (H2). We found this to be the case with levator muscle activity, but not with corrugator.

Compared to the alone condition, observed participants had significantly lower levator activity. Social condition was a significant predictor of levator activity even after the variation due to individual differences, food image stimuli and acceptability were statistically controlled for. This finding is consistent with previous research that detail how displays of negative emotion are inhibited in the presence of others (Jakobs et al., 2001; Lee & Wagner, 2002; Vingerhoets, Boelhouwer, Van Tilburg, & Van Heck, 2001). The inhibition of negative displays can be interpreted as evidence for a general display rule that it is inappropriate to reveal negative affect in the presence of a stranger or figure of authority. According to Basic Emotions Theory (BET) (Ekman & Friesen, 1971; Izard, 1971), facial displays are considered readouts of underlying affective states, their intensity modulated by culturally-specific display rules such as the one above. Some authors prefer accounting for this finding with role and impression management theories, arguing that BET disregards the complexities of social interaction (Lee & Wagner, 2002; Wagner, Lewis, Ramsay, & Krediet, 1992). Decreased levator response in the observed condition could have resulted from a desire to appear emotionally unaffected by the unpleasant images, or from a desire to affiliate with the experimenter. An alternative explanation of this finding is that by chance, participants in the Alone condition may have been more disgust sensitive than participants in the Observed condition. Individuals scoring higher on The Disgust Sensitivity Scale (Haidt, McCauley, & Rozin, 1994) display stronger levator muscle activation in response to disgusting pictures from the IAPS (Schienle, Stark, & Vaitl, 2001). Future studies should include a measure of disgust sensitivity to rule out this explanation.

The lack of evidence for corrugator inhibition could be due to several reasons. Corrugator fixation activity was higher in the observed condition compared to the alone condition, possibly masking a true difference between groups. It is also possible that the light levels between conditions were not sufficiently controlled for. Participants in the observed condition were seated in the main lab with natural light as well as ceiling lights while participants in the alone condition were in a testing booth with ceiling lights only. It is also possible that the monitor may have been brighter in the observed condition. Additional brightness may have induced participants to squint, activating the corrugator muscle throughout the experiment. Furthermore, frowning is not only an indication of negative affect; it is also an expression of physical and mental effort (Cacioppo, Petty, & Morris, 1985; de Morree & Marcora, 2010; Silvestrini & Gendolla, 2009; Smith, 1989; Van Boxtel & Jessurun, 1993; Waterink & Van Boxtel, 1994). With the experimenter seated beside them, observed participants may have felt a greater need to focus or appear focused on the task. In exploratory analyses (Appendix C), an interesting, albeit non-significant ($p = 0.06$, $d = 0.09$), relationship was found between social condition and corrugator rise time to peak. Corrugator took 178ms [-4, 361] longer to reach peak activity in the observed condition compared to the alone condition in our sample. This suggests that corrugator inhibition may be temporal in nature. Oda and Isono (2008) demonstrated that an accelerated progression from a neutral face to an angry face was judged to be more intensely angry compared to a linear progression. A quick furrow of the brow may signal hostility while a slower frown may be more likely to be interpreted as concentration or confusion, even though mean muscle activation is the same in both expressions. This exploratory finding highlights the need for more confirmatory research detailing the temporal dynamics of facial affective responses.

Consistent with earlier findings (Armstrong et al., 2007; Cannon et al., 2017; Horio, 2003; Hu et al., 2000; Hu et al., 1999), our results evidenced a relationship between facial muscle activity and hedonic ratings of food stimuli and the direction of effects were as expected – increased zygomaticus, decreased corrugator and decreased levator activity predicted increased LAM ratings. The size of these effects is small but consistent, even after accounting for the large variation in muscle activation due to individual differences in expressivity and acceptability of the food stimuli. Comparing the model estimates of the fixed effects, it appears that corrugator

(-0.18) has the strongest relationship with subjective liking, followed by levator (-0.10) and then zygomaticus (0.04). Social context (-0.14) appeared to have a greater influence on levator activity compared to the acceptability of the food stimuli (0.10). This might suggest that each muscle differs in the extent to which they express an underlying affective state or serve a social communicative function.

This study found evidence of a social context effect on facial affective responses to food images. However, the following limitations should be taken into account. Studies have shown that participants' BMI and hunger vs. satiety levels influence facial responses to food images (Hoefling et al., 2009; Soussignan et al., 2019). These factors were not measured and may be possible confounds. Although participants were blind to the social context manipulation, they were aware that their facial responses were being measured and may have exerted conscious control over their expressions. A cover story for the use of electrodes would have mitigated this limitation. Furthermore, given the large variation in participants' ages and the predominance of females in the sample, these findings should be cautiously generalised to the wider population.

In conclusion, this study demonstrated the importance of considering the influence of social presence when measuring implicit consumption emotions. Facial muscle activity indicative of disgust toward food images were inhibited in the presence of the experimenter. Given that consumer sensory and emotion evaluations are typically carried out in the presence of the researcher or a research assistant, this effect should be further explored with commonly employed emotion measurement methods.

4 Co-acting strangers but not friends influence subjective liking and facial affective responses to food stimuli

The following article was published by *Food Quality and Preference* in December 2019. The version shown is the accepted manuscript, with minor formatting changes for consistency with the rest of this thesis. References for this article are included within the consolidated reference list in section 8. Supplementary materials for this article are included in Appendix C (section 11). The final publication is available at Elsevier via the following citation.

Nath, E. C., Cannon, P. R., & Philipp, M. C. (2019). Co-acting strangers but not friends influence subjective liking and facial affective responses to food stimuli. Food Quality and Preference, 103865.

This study was also presented in a poster session at the 13th Pangborn Sensory Science Symposium in Edinburgh in July 2019. The poster is available online at the following link: https://osf.io/25bjc.

4.1 Abstract

In recent years, consumers' emotional responses have been found to be an important complement to sensory and hedonic evaluations for the prediction of food choice and consumption behaviour. Given this trend, it is essential that the influence of contextual variables on emotion are investigated. The present study contributes to the discussion with an investigation of the effect of social context on implicit emotional responses to food images. 87 participants (56 female, 31 male) viewed food images of varying acceptability either alone, with a stranger, or with a friend. Subjective liking ratings were measured using a labelled affective magnitude scale, and facial muscle activity from zygomaticus major (contracted during smiling), corrugator supercilii (contracted during frowning) and levator labii superioris (contracted during nose wrinkling) were measured with an EMG recording system. Controlling

for individual differences in facial expressivity and food image acceptability using linear mixed models, it was found that the presence of a co-acting stranger facilitated muscle activity indicative of a disgust response, increased the strength of relationship between muscle activity and subjective liking ratings, and led to lower subjective liking overall. No differences in muscle activity or subjective liking were found between subjects who participated alone and with a co-acting friend. This suggests that the influence of social context is complex, where the relationship between the subject and the social environment can impact both hedonic and emotional evaluations of food stimuli. These findings indicate that facial EMG can be a useful dynamic and implicit measure of emotion in consumer research, but it is critical to consider the social context of the testing environment.

4.2 Introduction

In recent years, there has been growing interest in emotion measurement in the field of consumer and sensory science. Studies have shown that emotional responses are an important complement to sensory and liking evaluations in the prediction of food choice and the discrimination of similar food products (Gutjar, Dalenberg, et al., 2015; Gutjar, de Graaf, et al., 2015; King & Meiselman, 2010; Ng et al., 2013). While emotion measurement is proving to be a valuable addition to consumer researchers' toolset, the trend has not been matched by equal attention to the numerous contextual variables that influence consumption-related emotion. One of these variables, the social context of the eating situation, is arguably a central element crucial to a greater understanding of food-evoked emotion.

The literature hints at the influence of social context on food-evoked emotion, although not much work has been done in this area. In a study on diners in a student cafeteria, Edwards et al. (2013) found that those who dined alone had higher negative self-reported emotions pre-meal. Although the meal reduced their negative feelings, they were still higher post-meal than those who ate in the company of others. In another study, Boothby et al. (2014) asked participants to taste sweet and bitter chocolate either alone or with a confederate posing as another participant. They found that the intensity of both pleasant and unpleasant sensory experiences was amplified when shared with another. In a study using evoked consumption contexts, Piqueras-Fiszman and Jaeger (2015a) found that for ice cream, the two most important variables were state of hunger and the interaction between location and social context, whereas for oranges, product format (whether the orange was peeled or whole) and location were more important. Their findings suggest that the influence of social context on emotion might vary based on the type of food in question.

The above studies used explicit measures of emotion to investigate the influence of social context. In consumer emotion measurement, there is a bias towards the use of explicit emotion measures such as questionnaires, interviews and focus groups because of their convenience and cost-effectiveness (Kaneko et al., 2018; Lagast et al., 2017). However, the insights gleaned by these measures are limited to the subjective experience component of emotion. Component theories of emotion postulate that in addition to subjective experience, there are four other fundamental components that constitute the emotion process – cognitive, neurophysiological, motivational and expressive (Scherer, 2005). These components are not readily available to conscious awareness and thus go undetected by explicit measurement methods. To capture the unconscious aspects of the emotion process, implicit methods such as functional neuroimaging, skin conductance measurement, and facial expression analysis are employed instead. These measures may confer significant value to our understanding of food choice and consumption. Köster (2003) argues that as consumers, we do not make reasonable and rational choices. Rather, our choices operate at an unconscious level, which we later rationalise consciously if asked to do so. Indirect or implicit measures that target unconscious decision-making may have stronger relationships to subsequent behaviour. Implicit emotion measures also allow us to capture consumers' responses in the moment. By nature of their design, explicit emotion measures only report on retrospective responses, while implicit measures allow us to capture consumers' involuntary responses in the moment, across the entire consumption process. One implicit emotion measure commonly used in the general emotion literature but underused in consumer emotion research is facial electromyography (EMG). Facial EMG involves the placement of electrodes on the surface of the skin which record the electrical activity generated by underlying muscles when they contract. Its main advantage over video facial expression analysis tools is its ability to capture subtle facial movements that accompany weak emotional responses such as those toward food stimuli.

In studies that have investigated how food-evoked implicit emotion is influenced by social context, the focus has been primarily on the presence of an unfamiliar or evaluative audience. For example, Jäncke and Kaufmann (1994) measured EMG activity while participants smelled pleasant and unpleasant odours either in private or with the experimenter sitting in front of them. They found that both positive and negative facial displays were amplified in the presence of the experimenter. Coming to similar conclusions, Gilbert et al. (1987) found that naïve raters were more accurate at determining the valence of odours smelled by participants when participants were aware they were being filmed. In contrast, other studies have found that negative facial displays to odours (Soussignan & Schall, 1996) and food images (Nath, Cannon, & Philipp, 2019) were inhibited in the presence of an unfamiliar adult. Although not in consensus as to the direction of effects, these studies demonstrate a strong rationale for more research in this area, especially considering the difficulty in completely eliminating the sociality of typical consumer test settings.

In addition to the effects of an unfamiliar or evaluative presence, other types of social relationships have also been shown to influence facial expression to emotional stimuli. Given the scarcity of consumer research in this area, we look to the general emotion literature to understand these effects. One of the earliest studies on social relationships and facial expression, Wagner and Smith (1991) manipulated social context by having female participants view slides with emotional content with a friend or with a stranger. Their facial expressions were covertly filmed and then shown to raters to guess the type of emotional content that had been viewed. Measurements of rater accuracy indicated that women were more expressive in the company of a friend than in the company of a stranger, but this pattern was not uniform across all emotions. Using a similar methodology, Buck, Losow, Murphy, and Costanzo (1992) found that compared to viewing emotional stimuli alone, the presence of strangers inhibited facial displays in general, while friends facilitated some expressions and inhibited others. Looking at positive stimuli specifically, Jakobs et al. (1999) had pairs of friends or pairs of strangers tell each other a funny story. Smiling activity as measured using FACS (facial action coding system) was greater when listening to a friend compared with listening to a stranger. With negative stimuli, it was found that people display less negative expressions in the presence of both friends and strangers, and that smiling was still increased in the presence of friends (Jakobs et al., 2001). In summary, it appears that friends amplify positive and reduce negative facial displays, while strangers inhibit both positive and negative displays. It is unclear if the reduction in negative facial displays is greater in the presence of friends or strangers. In the present study, we measured the expressive component of the emotion process using facial electromyography (EMG). Facial expression is the one dimension of emotion that has a clear social communicative function. As such, any potential social context influences on emotion would be reflected here. The literature suggests that facial expression is better able to inform us about disliking rather than liking (Cannon et al., 2017; Danner et al., 2014; Horio, 2003; Zeinstra et al., 2009), but we expect that increasing the sociality of the test environment will amplify the experience and result in a stronger relationship between positive expression and subjective liking. Characterising the effects of social context on hedonic and emotional evaluations of food stimuli will help to inform future consumer testing design.

Consistent with the literature reviewed, we hypothesized that the presence of a co-acting friend will facilitate positive expression and inhibit negative expression toward food images. Additionally, we hypothesized that the presence of a co-acting stranger will inhibit both positive and negative expression. In line with previous research (Fridlund, 1991; Hersleth, Ueland, Allain, & Næs, 2005; King, Meiselman, Hottenstein, Work, & Cronk, 2007; King, Weber, Meiselman, & Lv, 2004; Philipp et al., 2012), we did not expect to find a relationship between social context and subjective liking.

4.3 Method

4.3.1 Participants

Ninety-six participants (61 female, 35 male) were recruited via advertisements placed around the university campus and on local community Facebook groups. Advertisements were in English and asked for participants to be 18 years and older. No other exclusion criteria were stipulated. Participants were aged between 18 and 72 (M = 27.4, SD = 10.5) and were primarily of Asian (41.4%) and NZ European (32.3%) descent. All participants gave written consent and were compensated for their time with a supermarket gift card to the value of NZD$15. Power analysis calculations were run in R based on a dataset from a previous study conducted at this laboratory (Nath et al., 2019). The standardised Cohen’s d effect size for subjective liking was set at 0.1, standardised Cohen’s d effect sizes for muscle activity were set at 0.2 and the standardised Cohen’s d effect size for social condition was set at 0.3 – this is a conservative estimate based on the effect sizes for social condition found by Fridlund (1991) [0.5] and Philipp et al. (2012) [0.9]. All power curve analyses revealed that a sample size of 30 in each condition would be sufficient to achieve 80% power, therefore, a sample size of 90 was chosen. After the conclusion of data collection, it was discovered that the data from nine participants were lost due to technical complications. Data collection was not extended and only the data from the remaining eighty-seven participants (56 female, 31 male) were used in the analyses. Of these eighty-seven participants, 31 were in the Alone condition, 31 in the Friends condition, and 25 in the Strangers condition.

4.3.2 Design

Participants were randomly assigned to one of three experimental conditions: Alone, Friends or Strangers. Upon expressing interest in the study, potential participants were emailed a study information sheet describing the experimental procedure. The information sheet explained that the purpose of the study was to investigate facial behaviours in response to food images and as such, participants were blind to the social context manipulation. Using a random number generator, one-fifth of those who expressed interest were assigned to the Friends condition, two-fifths to Strangers condition, and the remainder to the Alone condition. Those assigned to the Friends condition were told that they were required to invite a friend to participate with them. They were asked that this be someone that they regularly have meals with – a partner, family member or friend. Those assigned to the Strangers and Alone conditions were emailed separate schedules of available session times to choose from (64% of participation was in the condition as originally assigned). Participants in the Alone condition sat the experiment with no other participants in the testing booth; those in the Friends condition participated with a friend or family member of their own choosing; and those in the Strangers condition were randomly paired with another participant also assigned to that condition. None of the participants in the Strangers condition expressed recognition of the participant they had been paired with. The experiment was conducted in a sound-attenuated testing booth with a table, two chairs and a computer screen. Participant pairs in the social conditions sat side-by-side, approximately 40 to 45cm apart from shoulder to shoulder, and were asked not to turn their faces away from the computer monitor as this would disrupt the electrodes. On visual inspection of the data, the absence of large movement artifacts confirmed that participants had not turned to face each other during data collection.

4.3.3 Stimuli

Thirty food images were selected such that their perceived acceptability would likely be distributed along the entire valence scale (ranging from greatest imaginable like to greatest imaginable dislike). In their study on food images and acceptability conducted in Auckland, New Zealand, Li (2017) found that the local sample rated images of familiar foods such as cake, roast chicken and chocolate highest in acceptability and rated images of unfamiliar foods from foreign cultures such as Balut (Philippines) and Svið (Iceland) lowest in acceptability. The images were presented with PsychoPy (Peirce, 2007) on a 60.5cm Philips monitor with 1920x1080 resolution and a 60Hz frame rate. The timing of trial events was synchronised with the psychophysiological recording software via parallel port. All images used in the present study are licensed for reuse and are included in Appendix C.

4.3.4 Measures

4.3.4.1 Subjective liking ratings

Subjective liking was measured using the labelled affective magnitude scale (LAM) (Schutz & Cardello, 2001) to measure food liking. The LAM is a vertical line scale with 11 semantic anchors ranging from “greatest imaginable dislike” at the bottom, to “greatest imaginable like” at the top. Compared to a 9-pt hedonic scale, the LAM provides slightly greater discrimination at the top end of the scale. The LAM scale, visualised in Figure 6, was presented on 7-inch hand-held Samsung Galaxy Tab3 tablets.

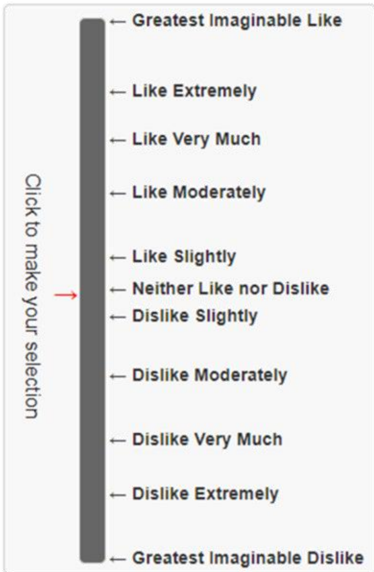


Figure 6. LAM response scale presented on 7 inch hand-held Samsung Galaxy Tab3 tablets.

4.3.4.2 Facial Electromyography

Muscle activity from zygomaticus major (contraction lifts corner of mouth during smiling), corrugator supercilii (contraction knits brow during frowning) and levator labii superioris (contraction wrinkles nose during expressions of disgust) (Fridlund & Cacioppo, 1986) on the left side of the face was recorded using a BIOPAC MP150 physiological recording device, three BIOPAC amplifiers, and six 4mm Ag/AgCl reusable surface electrodes (BIOPAC Systems Inc., Goleta, CA). An 8mm ground electrode was attached to the forehead near the hairline.

4.3.5 Procedure

On arrival at the lab, each participant was asked to sign a consent form and were given a NZD$15 supermarket gift card. To prepare the skin sites for electrode adhesion, participants were first asked to wash their face with a mild facial cleanser. Then, the skin sites were cleaned with an alcohol swab and abraded with an abrading pad. A small amount of electrode gel was applied to each skin site with a cotton bud and any excess gel was wiped off with a tissue.

Once the electrodes were attached to the participant (in the alone condition) or both participants (in the social conditions), they were directed to sit in front of a computer monitor in a sound-attenuated testing booth. The participants' chairs were positioned such that their faces were between 60 and 70cm from the monitor. The experimenter ran a simulation of the experiment and demonstrated response requirements before starting the experiment. The experiment consisted of thirty trials presented consecutively. The order of trial presentation was randomised for each experimental session. Each trial consisted of a fixation screen displayed for 5000ms, a food image displayed for 5000ms, followed by a screen prompting participants to make their rating on their tablet displayed for 10000ms. During the rating screen, participants were required to indicate their liking on individual tablets then turn their attention back to the computer monitor to await the next trial. After participants rated all thirty food images, maximum facial muscle contractions were recorded with the aid of on-screen prompts to pose a frown, wrinkle the nose and smile. Finally, the experimenter removed the electrodes and debriefed participants, explaining the true aims of the study.

4.3.6 Data processing

The EMG signals were relayed through shielded cable to Biopac amplifiers set to a gain of 5000 with a high pass filter at 1Hz. The signal was digitally recorded at 2000Hz using Acqknowledge 4.2 software. Raw data files were uploaded after the data collection phase to a Zenodo online depository and are available under the Creative Commons Attribution Share-Alike 4.0 licence. Offline, Butterworth second order filters were applied using the biosignalEMG package (Guerrero & Macias-Diaz, 2018) in R (R Core Team, 2017). The filters consisted of a high pass filter at 20Hz to remove movement artifacts and unstable low frequency muscle activity, a low pass filter at 500Hz to remove noise above the upper limit of muscular electrical potential, and band stop filters every 50Hz to remove mains frequency interference and harmonics. The signal was then rectified and smoothed. Each data point was converted to a percentage of the peak maximum contractions for each muscle. Changescores were then calculated by subtracting the mean muscle activity of the last 500ms of the fixation period from the mean muscle activity of the full 5000ms of the subsequent food image presentation period. This was then converted to z-scores. Multivariate outliers computed using Mahalanobis distance were excluded from all analyses (4.1% of total trials). Individual data points were also excluded if the fixation muscle activity was 2 standard deviations above the fixation mean for that participant (4.8% of total data points).

4.3.7 Data analysis

Linear mixed-effects models were used to investigate the effect of social presence on muscle activity. These are able to account for individual differences in facial expressivity and rating scale response style between participants as well as the differences between food images as elicitors of liking and affect. Muscle activity for each muscle was considered as dependent variables, subjective liking was considered a continuous fixed effect, and Condition was considered a categorical fixed effect. Individual participants and individual food images were considered single-level random effects (please refer to Appendix C for the statistical notation and lmer specification for these models).

A maximum likelihood estimation approach was used throughout to compare models using a chi square test on model likelihood. Confidence intervals for fixed effects were calculated using parametric bootstrapping based on 10,000 simulations of the fitted models. The 2.5% and 97.5% percentiles were extracted to give an estimate of the 95% confidence level for each effect. Standardised effects and confidence intervals are reported in the supplementary materials. An alpha level of $\alpha = 0.05$ was used for all analyses.

All statistical analyses and modelling were conducted in R (R Core Team, 2017). Specifically, the lme4 package (Bates et al., 2015) was used to estimate linear mixed model effects, figures were generated using ggplot2 (Wickham, 2009) and yarr (Phillips, 2017), and tables were generated using stargazer (Hlavac, 2018).

4.4 Results

4.4.1 Preliminary analyses

Maximum contractions for all three muscles did not differ between conditions (all $p>.05$). Fixation muscle activity for corrugator supercilii and levator labii superioris did not differ between conditions, but there was a significant effect of social context on zygomaticus major activity ($F(2, 81) = 4.71$, $p = 0.01$, $\eta^2 = 0.10$). Post hoc comparisons using a Tukey HSD test indicated that fixation zygomaticus activity was greater in the Friends condition compared to the Alone condition ($M_{Diff} = 0.72$, 95% CI [0.13, 1.31], $p = 0.01$). Fixation zygomaticus activity in the Strangers condition did not significantly differ from the Alone ($M_{Diff} = 0.58$, 95% CI [-0.05, 1.21], $p = 0.07$) or Friends ($M_{Diff} = -0.14$, 95% CI [-0.77, 0.49], $p = 0.86$) conditions.

4.4.2 Facilitation and inhibition of facial muscle activity

To investigate if positive facial muscle activity was facilitated and negative facial muscle activity inhibited by social context, three models of increasing complexity were specified for each muscle. Inspecting the intra-class correlation coefficients of the models, it was clear that muscle activity was clustered by participant and by food image albeit to varying degrees (see Table 16 in Appendix C). Therefore, within all the models, participant and food image are included as random intercepts, allowing for between subjects and between stimuli variation in muscle activation. The first model was a null model. The second model included subjective liking as a continuous fixed effect. The third and final model built on the second by including social condition as an interaction term.

Entering subjective liking into the model resulted in an improved likelihood for corrugator, $\chi^2(1)_{corrugator}=52.51$, $p<0.001$, and levator, $\chi^2(1)_{levator}=17.26$, $p<0.001$, but not for zygomaticus, $\chi^2(1)_{zygomaticus}=0.09$, $p=0.77$. An increase of one standard deviation in subjective liking resulted in a 0.15 [0.11, 0.18] standard deviation decrease in corrugator activity and a 0.09 [0.05, 0.12] standard deviation decrease in levator activity. Adding social condition as an interaction term improved the model likelihood for corrugator, $\chi^2(4)_{corrugator}=9.65$, $p=0.047$, and levator, $\chi^2(4)_{levator}=12.16$, $p=0.02$, but not for zygomaticus, $\chi^2(4)_{zygomaticus}=8.09$, $p=0.09$.

Social condition also appeared to influence the relationship between mean muscle activity and subjective liking (see Figure 7 and tables 17-19 in Appendix C). An increase of one standard deviation in subjective liking in the Strangers condition resulted in 0.10 [0.04, 0.17] standard deviations less corrugator activity and 0.09 [0.02, 0.15] standard deviations less levator activity than a corresponding increase in the Alone condition. Compared to the Friends condition, an increase of one standard deviation in subjective liking in the Strangers condition resulted in 0.08 [0.02, 0.14] standard deviations more zygomaticus activity and 0.08 [0.01, 0.15] standard deviations less corrugator activity. An increase of one standard deviation in subjective liking in the Friends condition resulted in 0.07 [0.01, 0.13] standard deviations less levator activity than a corresponding increase in the Alone condition. Participants in the Strangers condition showed 0.25 [0.04, 0.46] standard deviations greater levator activity overall compared to participants in the Alone condition.

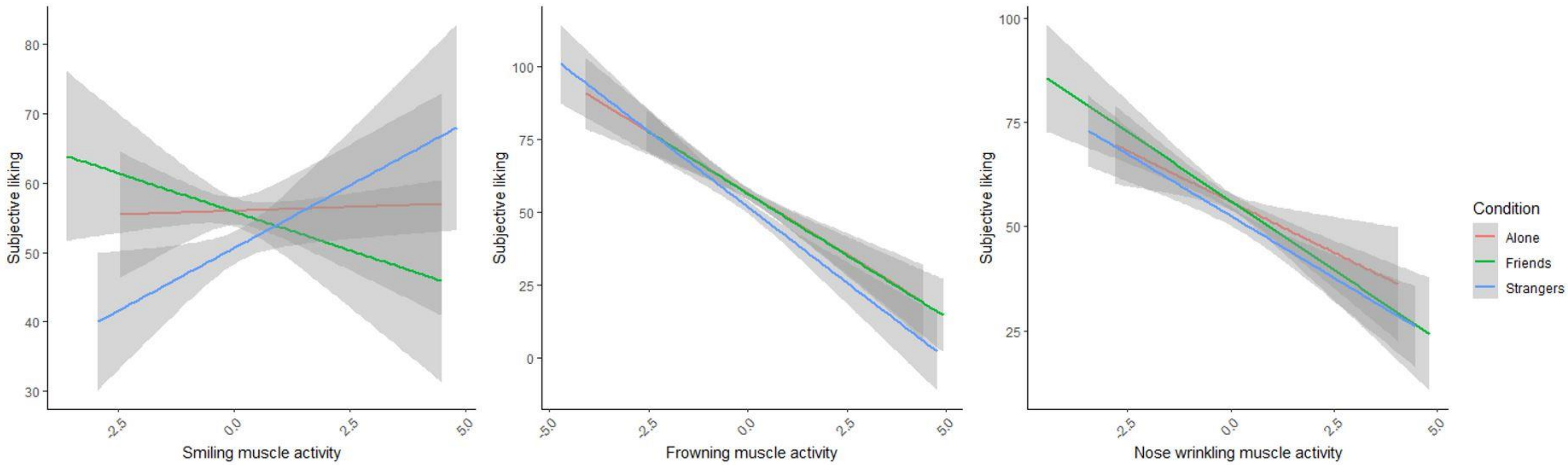


Figure 7. The relationship between subjective liking and standardised mean muscle activity changescores by social condition.

4.4.3 Social context and subjective liking

Subjective liking differed between groups ($F(2, 2483) = 4.96$, $p = 0.01$, $\eta^2 = 0.004$). Participants in the Strangers condition rated the food images lower in liking than participants in the Friends condition ($M_{Diff} = -4.56$, 95% CI [-8.05, -1.07], $p = 0.006$). There was no difference in subjective liking between the Friends and Alone ($M_{Diff} = -1.15$, 95% CI [-2.13, 4.43], $p = 0.69$) and the Strangers and Alone conditions ($M_{Diff} = -3.41$, 95% CI [-6.87, 0.06], $p = 0.06$).

4.5 Discussion

The results of the present study provide evidence that social context influences facial affective responses to food stimuli; however, the direction of effects was not as expected. Preliminary analyses revealed that maximum voluntary contractions and fixation muscle activity were similar across the experimental groups. This allows us to be confident that any differences found are due to the social context manipulation and not due to inherent overall differences in facial reactivity between conditions.

4.5.1 Facilitation and inhibition of facial muscle activity

It was hypothesized that zygomaticus major activity would be amplified in the Friends condition compared to the Alone condition. This was not demonstrated by our results. Our study did not evince overall differences in smiling muscle activity between groups, however, we did find that smiling muscle activity was the most aligned with stimuli valence in the Strangers condition. A possible explanation for this is that participants in the Strangers condition might have felt more motivated to align their facial displays with socially accepted patterns of responding – positive expressions to positive stimuli and negative expressions to negative stimuli. Jakobs et al. (1999) proposed that social context effects are due to differences in social motives and demonstrated this in a study measuring facial activity and intention to express one's feelings. For strangers, there existed a strong relationship between social motives and facial activity, but with friends, this relationship only reached marginal significance. In this view, our results suggest that perhaps for food stimuli, the intention to communicate preference is higher in the presence of strangers compared to friends. There is also the possibility that the smiles displayed in the Strangers condition might have differed functionally from the smiles in the Friends condition should not be overlooked. Jakobs et al. (1999) distinguished between Duchenne smiles with orbicularis oculi activity (creasing the corners of the eyes) and non-Duchenne smiles. Smiles involving the orbicularis oculi are thought to be smiles of enjoyment (Duchenne & de Boulogne, 1990; Frank, Ekman, & Friesen, 1993), while those only activating zygomaticus major are more likely to be perceived as “posed” or “polite” smiles (Gunnery & Ruben, 2016). Future research into social context could record activity from both zygomaticus major and orbicularis oculi to better understand if the presence of friends and strangers influence these muscles differently.

It was also hypothesized that corrugator supercilii and levator labii superioris activity would be inhibited in social conditions compared to the alone condition. The results did not support this. In fact, levator labii superioris activity was higher in the Strangers condition compared to the Alone condition. These results appear to contradict our findings from a previous study conducted at the same laboratory where we found that an unfamiliar presence reduced levator activity compared to the Alone condition (Nath et al., 2019). However, it must be emphasised that the social relationship between the expresser and their audience are functionally distinct in these two cases. In the present study, the role of the other is that of co-actor, while in the previous study, the role of the other is that of an evaluative observer. These results highlight the intricacy of social context effects on facial displays and underscore the need for further investigations in this area. Comparable with our inferences for zygomaticus activity, an explanation for increased levator activity in the Strangers condition might also be due to participants’ feeling more highly motivated to display socially appropriate expressions towards unpleasant food images. With friends, they might have felt more comfortable laughing or showing surprise. Alternatively, the calming presence of a friend may have reduced negative emotional responses to the unpleasant stimuli. This effect is well documented in the literature (eg. Adams, Santo, & Bukowski, 2011; Christenfeld et al., 1997; Master et al., 2009).

Corrugator supercilii activity had the strongest relationship with subjective liking but did not appear to be influenced by social context, suggesting that this muscle might have less of a social-communicative function than the others. This idea has been expressed in previous studies. In a sample of depressed and non-depressed adults, Gehricke and Shapiro (2000) did not find any social context effects on frowning muscle activity in both groups, although smiling muscle activity varied with social context. In dyadic face-to-face interactions, it has been demonstrated that smiling muscle activity rapidly synchronises between pairs but that frowning muscle activity does not (Riehle, Kempkensteffen, & Lincoln, 2017). Taken together, these findings suggest that some facial muscles are more sensitive to the social environment than others. Another possibility for the lack of corrugator differences between groups could be the fact that frowning is not only an indication of negative affect; it is also a demonstration of physical and mental effort (Cacioppo et al., 1985; de Morree & Marcora, 2010; Silvestrini & Gendolla, 2009; Smith, 1989; Van Boxtel & Jessurun, 1993; Waterink & Van Boxtel, 1994). The rapid series visual presentation of stimuli at five seconds per trial requires high cognitive demand. Therefore, if corrugator activity was capturing task effort in this case, we would not expect it to differ between groups.

The finding that the presence of a co-acting stranger strengthened the relationship between facial muscle activity and subjective liking was not expected. Previous studies have found that emotions are expressed more freely in the presence of friends compared with strangers (Buck et al., 1992; Jakobs et al., 1999; Wagner & Smith, 1991). This result hints at a greater complexity of the interaction between sociality and emotion than could be captured by our measures. Participants may have felt comfortable expressing “inappropriate” emotions (i.e. amusement in response to disgusting stimuli) with friends but amplified expressions of socially appropriate emotions when with a stranger. The Behavioural Ecology View of facial expression (Fridlund, 1992, 1997, 2002) provides an explanation of this result. According to this view, facial displays are primarily social communication tools. Given that a stranger would require more cues than a friend would to decipher our emotional evaluation of a situation, expressed emotion would be more likely to be facilitated in the presence of a stranger. In a previous study conducted at this laboratory using the same food stimuli, we found that the presence of the experimenter did not result in a stronger relationship between facial muscle activity and liking ratings (Nath et al., 2019). Taken together, these findings suggest that facial muscle activity may be facilitated only in the presence of a co-acting stranger and not in the presence of a co-acting friend or an observer. Jakobs et al. (1997) emphasize the importance of considering the role of the other when investigating social context. They found differences in self-reported emotional reactions towards emotional vignettes in which a friend was present as an observer versus present as a co-experiencer. However, to date, there is no existing empirical study describing differences in emotion when in the presence of an unfamiliar peer versus an unfamiliar observer. This would be an important line of future research for consumer and sensory science as these are the social contexts most commonly encountered in consumer testing environments.

4.5.2 Social context and subjective liking

We expected that social condition would not have an influence on subjective liking ratings. However, the results revealed that overall, participants in the Strangers condition rated the food images 5 points less than participants in the Friends conditions on average. This finding is inconsistent with previous studies that have found no effect of social context on hedonic ratings (Fridlund, 1991; Hersleth et al., 2005; King et al., 2007; King et al., 2004; Philipp et al., 2012). One possible reason for this result is that facial feedback could have influenced liking ratings, given the higher levator activation in the Strangers condition compared to the Alone condition.

The facial feedback hypothesis proposes that feedback from facial muscles plays an important role in the subjective experience of emotion (Buck, 1980; Ekman & Oster, 1979; McIntosh, 1996; Tourangeau & Ellsworth, 1979). In the absence of other cues essential for determining food liking (smell, taste, temperature etc.), socially-facilitated disgust expressions in the Strangers condition might have precipitated lower subjective liking ratings.

4.5.3 Limitations and future directions

This study found evidence of a social context effect on facial affective responses to food images. However, the following limitations should be taken into account. Firstly, previous research has shown that participants' BMI and hunger vs. satiety levels influence facial responses to food images (Hoefling et al., 2009; Soussignan et al., 2019). These factors were not measured in the present study and may be possible confounds. Secondly, although participants were blind to the social context manipulation, they were aware that their facial responses were being measured and may have exerted conscious control over their expressions. A cover story for the use of electrodes would have mitigated this limitation. Thirdly, the loss of data for nine participants decreased the power of the study, impacting the reliability of the reported results. Lastly, given the large variation in participants' ages and the predominance of females in the sample, these findings should be cautiously generalised to the wider population.

4.5.4 Conclusion

In summary, the present study showed that facial affective responses to food stimuli was facilitated by the presence of a co-acting stranger, but not by a co-acting friend. Furthermore, participants’ facial muscle activity aligned most with their subjective liking ratings in the presence of a co-acting stranger. Future research should investigate this social context effect with other implicit and explicit measures of emotion. The findings of this study prompt consumer researchers to consider the social context of their testing environment during hedonic and emotion measurement.

5 The influence of social context on the temporal dynamics of facial affective responses: rise to peak and return to baseline

The exploratory findings in this chapter was presented orally at the 46th Annual Conference of the Australasian Society for Experimental Psychology in Wellington, New Zealand in April 2019. There is no intention to submit this thesis chapter for publication.

5.1 Introduction

The dominant theoretical perspectives on emotion agree that emotions are dynamic, multi-componential processes. In early research into emotion, researchers often ignored the dynamic aspect of emotion experiences and used self-report measures that captured retrospective subjective feelings at a single point in time. This resulted in the compression of rich longitudinal psychophysiological data into single average values. With the rise of sequential appraisal theories of emotion and more sophisticated statistical tools, greater research attention is being directed to the temporal dynamics of emotion.

In the case of facial expression research, a growing body of evidence points to the importance of using ecologically valid, dynamic facial expression stimuli over static images (Krumhuber et al., 2013). Dynamic presentations of facial expression leads to enhanced neural activation (Kilts, Egan, Gideon, Ely, & Hoffman, 2003; Sato, Kochiyama, Yoshikawa, Naito, & Matsumura, 2004) and facial muscle mimicry (Rymarczyk, Biele, Grabowska, & Majczynski, 2011; Sato, Fujimura, & Suzuki, 2008) compared to static facial stimuli, and allows individuals to better discriminate between subtle differences in expression (Ambadar, Schooler, & Cohn, 2005; Cohn et al., 2004; Krumhuber & Kappas, 2005; Wehrle et al., 2000). In an fMRI study where participants were shown videos of fear expressions, Reinl and Bartels (2014) found that face processing areas of the brain (the superior temporal sulcus, the fusiform face area, and the occipital face area) were highly attuned to natural vs. unnatural progressions of expression. Considered together, these studies suggest that dynamic emotional experiences are more effective sources of social information for participants compared with static emotional expressions used in earlier research—these stimuli have the added benefit of resulting in higher ecologically validity.

Given that the recognition and differentiation of facial expression is sensitive to timing, it is not a surprise that the intensity of facial expressions varies across the duration of an emotional experience as well. Studies that have reported the temporal unfolding of facial displays generally conclude that negative expressions have earlier onsets compared to positive expressions. Gentsch, Grandjean, and Scherer (2014) investigated brain activity and facial muscle activity in response to reward stimuli in a gambling task. Activity in the frontalis (raises the eyebrows in surprise expressions) and corrugator supercilii (contracts the brow in frowning expressions) muscles in the upper face differentiated wins and losses at 200-300ms after stimulus presentation, while zygomaticus major (raises the corners of the mouth in smiles) muscle activity did so at 350-600ms. He et al. (2014) measured facial expressions to odours using a facial expression recognition software. They found that neutral expressions differentiated odours after 100ms, followed by expressions of disgust at 180ms and anger at 500ms, while happy expressions only differentiated odours from 1780ms onwards.

Perhaps one of the main drivers behind the growth in temporal dynamic emotion research is a 1998 article on affective style and affective chronometry (Davidson, 1998). In this article, Davidson emphasized the importance of parameters of emotional responding such as rise time to peak and recovery time to the understanding of affective disorders. Since then, studies have indeed characterised how these variables are implicated in depression (Dichter & Tomarken, 2008; Taubitz, Robinson, & Larson, 2013), borderline personality disorder (Jennings, 2003) and schizophrenia (Kring, Germans Gard, & Gard, 2011; Volz, Hamm, Kirsch, & Rey, 2003). In addition to the effects of psychopathology, studies have also shown that individual factors like age (Burton, 2003; Wrzus, Müller, Wagner, Lindenberger, & Riediger, 2014) and gender

(Nolen-Hoeksema, 2012) influence the dynamics of the emotional experience. However, it is unclear if dynamic emotion variables are also influenced by external factors such as the social environment. In this chapter, we were interested in developing a rudimentary understanding of how social context affects facial expression dynamics. Specifically, we will discuss muscle activity rise to peak and return to baseline. These two variables can be thought of as relating to expression generation and expression regulation respectively.

5.2 Methods

Given that the same stimuli and experimental procedures were used in the experiments presented in chapters 3 and 4, the data from both studies were combined and analysed as one dataset in this chapter. For a detailed description of the stimuli, measures, procedure and data processing, please refer to the methods sections in chapters 3 and 4.

5.2.1 Participants

The data from 157 participants, 70 in study 1 and 87 in study 2, were used in the following analyses. Participants (108 female, 49 male) were aged between 18 and 74 (M = 28.0, SD = 10.3) and were primarily of Asian and NZ European descent.

5.2.2 Design

Participants in study 1 were randomly assigned to one of two experimental conditions – alone or observed. Participants in the alone condition were directed to sit in front of a computer screen in a sound-attenuated testing booth while participants in the observed condition were directed to sit in front of a computer screen beside the experimenter in the main lab. Participants in study 2 were randomly assigned to one of three experimental conditions: Alone, Friends or Strangers. Participants in the Alone condition sat the experiment with no other participants in the testing booth; those in the Friends condition participated with a friend or family member of their own choosing; and those in the Strangers condition were randomly paired with another participant also assigned to that condition. A breakdown of the number of participants in each condition is shown in table 3.

Table 3

Number of participants in each condition.

	Study 1		Study 2		
	Alone	Observed	Alone	Friends	Strangers
n	30	30	31	31	25

Participants' fixation and maximum voluntary contractions were comparable between the alone conditions of both studies, and comparable across all four conditions. These analyses are included in Appendix D.

5.2.3 Data analysis

A maximum likelihood estimation approach was used throughout to compare models using a chi square test on model likelihood. Satterthwaite approximations to degrees of freedom were used in all linear mixed model t-tests. Confidence intervals for fixed effects were calculated using parametric bootstrapping based on 10,000 simulations of the fitted models. The 2.5% and 97.5% percentiles were extracted to give an estimate of the 95% confidence level for each effect. Standardised effects and confidence intervals are reported in the supplementary materials. An alpha level of $\alpha = 0.05$ was used for all analyses.

5.3 Results

5.3.1 Rise time to peak

Prior to data collection, we specified exploratory analyses in our preregistrations for both studies (https://osf.io/4j6nv and https://osf.io/76wzv). We were interested in exploring the influence of social context on the rise *time* to peak. In these analyses, the models specified for each muscle were as follows. Peak muscle activity and Condition were consecutively added as predictors to the null model.

$$\text{rise time to peak} \sim 1 + (1|\text{participant}) + (1|\text{food image}) \tag{1}$$

$$\text{rise time to peak} \sim \text{peak muscle activity} + (1|\text{participant}) + (1|\text{food image}) \tag{2}$$

$$\text{rise time to peak} \sim \text{peak muscle activity} + \text{Condition} + (1|\text{participant}) + (1|\text{food image}) \tag{3}$$

In both studies, our results revealed a strong relationship between peak muscle activity and rise time to peak for all three muscles, however, social context did not account for any of the variability in rise time to peak (see tables 20-25 in Appendix D). This finding suggested that the speed or acceleration of facial muscle contractions are primarily determined by physiology, and not likely to be influenced by the social environment.

In hindsight, we realised two major limitations of these analyses. First, they did not take subjective liking into account and second, it would be more accurate to draw conclusions about the speed of expression by actually calculating the speed of rise to peak.

5.3.2 Speed of rise to peak

The speed of rise to peak was calculated by taking the difference between peak muscle activity and muscle activity at the start of the trial divided by the time it took to reach the peak. This is illustrated in Figure 8 below. Given the skewness of the data, these values were then log-transformed and converted to z-scores.

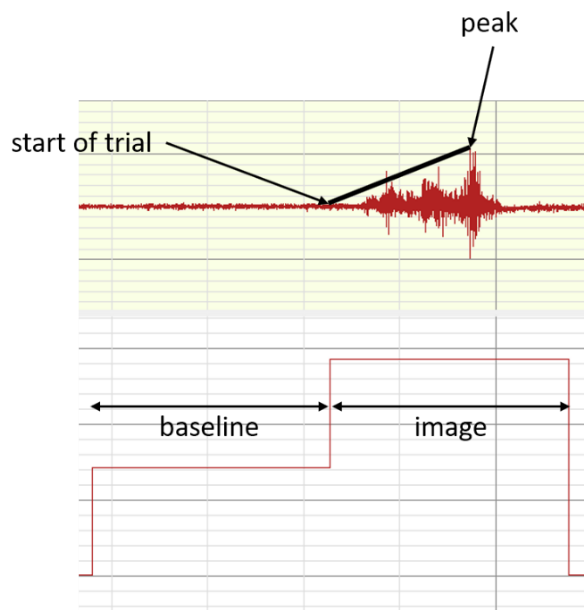


Figure 8. Illustration of speed of rise to peak calculation.

To investigate if social context influenced the speed of rise to peak, three models of increasing complexity were specified for each muscle.

rise to peak ~ 1 + (1|participant) + (1|food image) (1)

rise to peak ~ LAM + (1|participant) + (1|food image) (2)

rise to peak ~ LAM * Condition + (1|participant) + (1|food image) (3)

The first model is a null model with participant and food image as random intercepts. The second model adds LAM as a continuous fixed effect. The third model adds social condition as an interaction term. LMM coefficient tables are included in Appendix D.

Including LAM as a predictor improved the model likelihood for all three muscles over the null model, $\chi^2(1)_{zygomaticus}=4.43$, $p=0.04$, $\chi^2(1)_{corrugator}=54.05$, $p>0.001$, $\chi^2(1)_{levator}=33.79$, $p<0.001$. A one standard deviation increase in LAM resulted in a 0.04 standard deviation increase in zygomaticus rise to peak, a 0.17 standard deviation decrease in corrugator rise to peak and a 0.10 standard deviation decrease in levator rise to peak.

Including social condition as an interaction improved model likelihood for levator, $\chi^2(6)_{levator}$=13.59, p=0.03, but not for zygomaticus, $\chi^2(6)_{zygomaticus}$=5.68, p=0.46, or corrugator, $\chi^2(6)_{corrugator}$=8.63, p=0.20. Corrugator rise to peak in the Strangers condition was 0.30 standard deviations greater than in the Alone condition and 0.32 greater than in the Friends condition. Levator rise to peak in the Strangers condition was 0.40 standard deviations greater than in the Alone condition, 0.40 standard deviations greater than in the Observed condition, and 0.50 standard deviations greater than in the Friends condition.

5.3.3 Speed of return to baseline

The speed of return to baseline was calculated by taking the difference between peak muscle activity and the minimum muscle activity after the peak divided by the duration between those two points. This is illustrated in Figure 9 below. Given the skewness of the data, these values were then log-transformed and converted to z-scores.

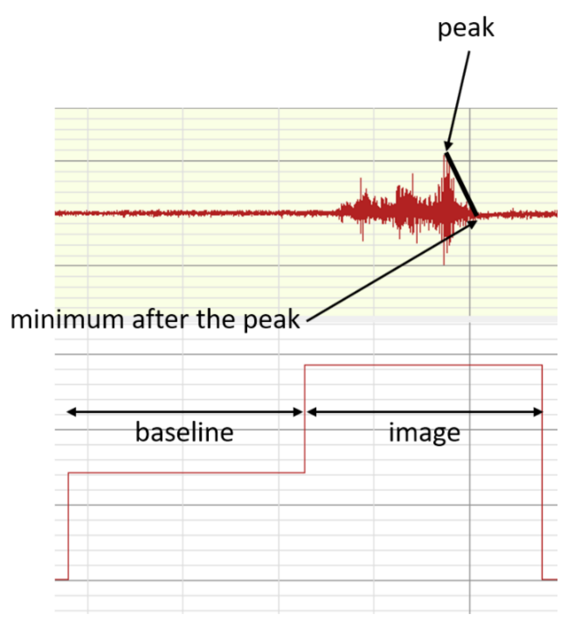


Figure 9. Illustration of speed of return to baseline calculation.

To investigate the influence of subjective liking and social context on the speed of return to baseline, the same three models defined above were specified for each muscle. LMM coefficient tables are included in Appendix D.

Including LAM as a predictor improved the model likelihood for corrugator, $\chi^2(1)_{corrugator}$=48.76, p<0.001, and levator, $\chi^2(2)_{levator}$=16.60, p<0.001 but not for zygomaticus, $\chi^2(1)_{zygomaticus}$=0.14, p=0.71. A one standard deviation increase in LAM resulted in a 0.16 standard deviation decrease in corrugator activity and a 0.07 standard deviation decrease in levator activity.

Including social condition as an interaction improved model likelihood for zygomaticus, $\chi^2(6)_{zygomaticus}$=13.68, p=0.03, and corrugator, $\chi^2(6)_{corrugator}$=12.67, p=0.05, but not for levator, $\chi^2(6)_{levator}$=9.75, p=0.14. Social condition did not have a direct effect on return to baseline but appeared to influence the strength of correlation between return to baseline and subjective liking (see tables 29-31 in Appendix D). An increase of one standard deviation in LAM resulted in a smaller increase in zygomaticus return to baseline in the Observed condition compared to the Alone (-0.09 SD), Friends (-0.10 SD) and Strangers (-0.11 SD) conditions, a larger increase in corrugator return to baseline in the Strangers condition compared to the Alone (0.09SD) and Observed (0.12SD) conditions, and a larger increase in levator return to baseline in the Friends conditions compared to the Observed condition (0.11SD).

5.4 Discussion

5.4.1 Speed of rise to peak

Subjective liking influenced speed of rise to peak for all three muscles, suggesting that rise to peak, along with mean muscle activity and peak muscle activity, is closely related to the subjective intensity of the emotional stimuli.

Participants in the Strangers condition generated corrugator activity faster than participants in the Alone and Friends condition, and generated levator activity faster than participants in all other conditions. This result implies that the presence of a co-acting stranger might speed up the generation of negative facial affective responses. The potential for social-evaluative threat has been shown to elevate sympathetic nervous system and cortisol responses (Bosch et al., 2009; Dickerson, Mycek, & Zaldivar, 2008). In our study, the presence of a stranger could have primed responses to negative stimuli. It should be noted that this result could also have been driven simply by greater overall muscle activity in the Strangers condition.

5.4.2 Speed of return to baseline

Subjective liking influenced speed of return to baseline for corrugator and levator but not zygomaticus. This suggests that the rate of decay of the emotion response is related to the intensity of the emotional stimuli for negative, but not positive facial affective responses.

For return to baseline, each of the muscles appeared to have a different relationship with social context and subjective liking. Zygomaticus return to baseline did not evince much of a relationship with subjective liking, except in the Observed condition. In the Observed condition, participants zygomaticus activity tended to last longer for liked images and diminish faster for disliked images. This effect could be due to participants in the Observed condition feeling a greater desire to display appropriate positive facial reactions in front of the researcher.

The relationship between corrugator return to baseline and subjective liking was generally consistent across social conditions, with activity lasting longer for liked images and diminishing quickly for disliked images. Corrugator return to baseline had the smallest relationship with subjective liking in the Strangers condition. This might mean that participants in the Strangers condition were more inclined to display appropriate negative facial reactions compared to the other conditions. Alternatively, this result could be primarily driven by greater overall corrugator activity for disliked images, and greater overall muscle activity in the Strangers condition.

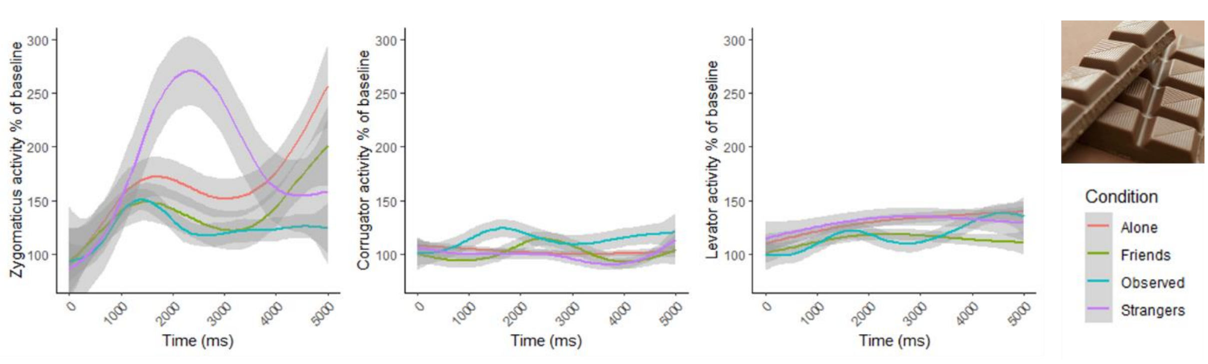
Levator return to baseline generally had a negative relationship with subjective liking, with activity lasting longer for liked images and diminishing quickly for disliked images. This is most likely driven by little to no levator response for liked images and large peaks for disliked images. Levator return to baseline in the Friends condition showed less of a relationship with subjective liking, pointing to a possible calming effect in the presence of a friend.

Hemenover (2003) found that rates of positive and negative self-reported affect decay were contingent on personality traits. Extraverts and emotionally stable participants had slower rates of positive affect decay and faster rates of negative affect decay compared to participants high on introversion and neuroticism. Future research could investigate how the speed of rise to peak and return to baseline of facial affective responses might be influence by personality as well.

5.4.3 The appropriateness of facial responses

While the social context effects on rise to peak and return to baseline were modest overall, the results suggest that facial displays to food stimuli may be driven by whether it is appropriate to express liking in that context or not. An exploration into the time series plots for individual food images appear to support this idea. The following time series plots depict loess curves of muscle activity as a percentage of baseline activity as a function of time in milliseconds. The grey bands represent 95% confidence intervals of the smoothed conditional means.

In the time series plots for chocolate and fruit salad (Figure 10), we observed large peaks of zygomaticus activity in individuals who participated with a stranger.



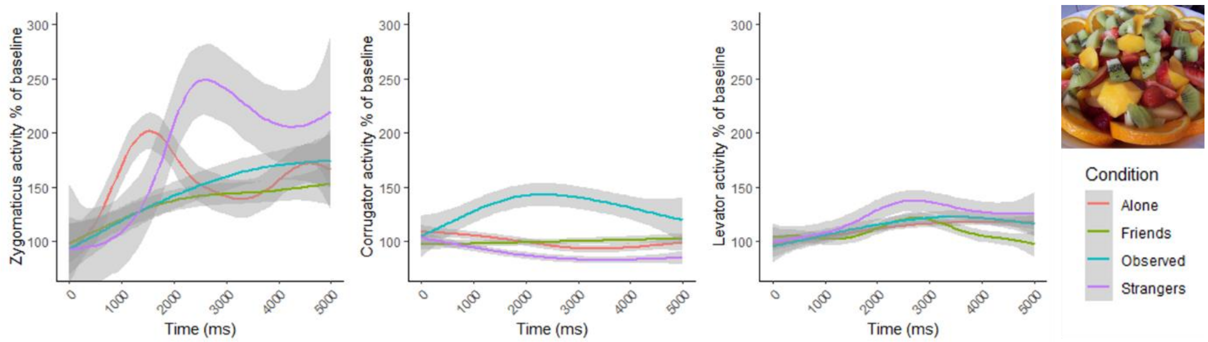
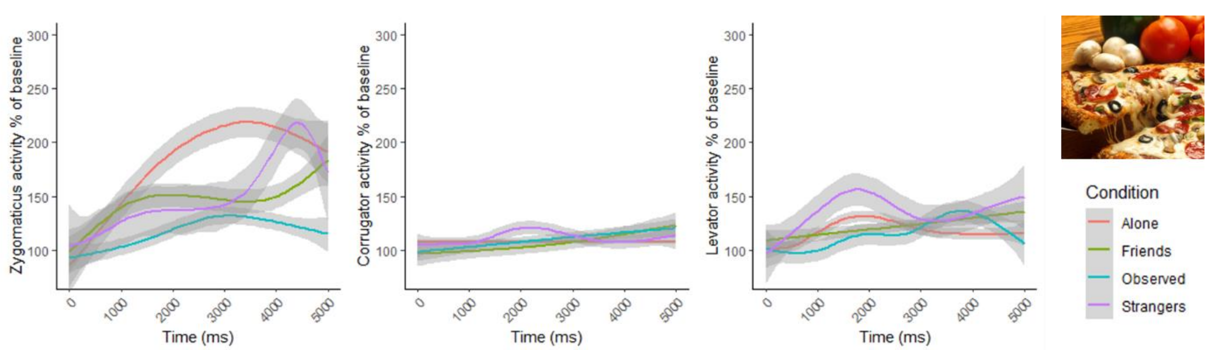


Figure 10. Facial muscle activity time series plots for chocolate and fruit salad by social condition.

The mean liking rating for chocolate was 79.92 and did not differ between conditions ($F(3, 128) = 1.76$, $p = 0.16$, $\eta^2 = 0.04$). The mean liking rating for fruit salad was 82.16 and did differ between conditions ($F(3, 137) = 3.41$, $p = 0.02$, $\eta^2 = 0.07$). Post hoc comparisons using a Tukey HSD test indicated that mean liking in the Alone condition was higher than in the Strangers condition ($M_{Diff} = 9.72$, 95% CI [1.68, 17.75], $p = 0.01$). It may be the case that expressing positive emotion towards common and generally well-liked foods such as chocolate and fruit serves a social affiliative function. This could explain the increased smiling muscle activity in the Strangers condition for these two food images, even though it did not align with differences in subjective liking.

In contrast, we observed the largest peaks for zygomaticus activity in the time series plots for pizza and burger in participants who viewed these images alone (Figure 11).



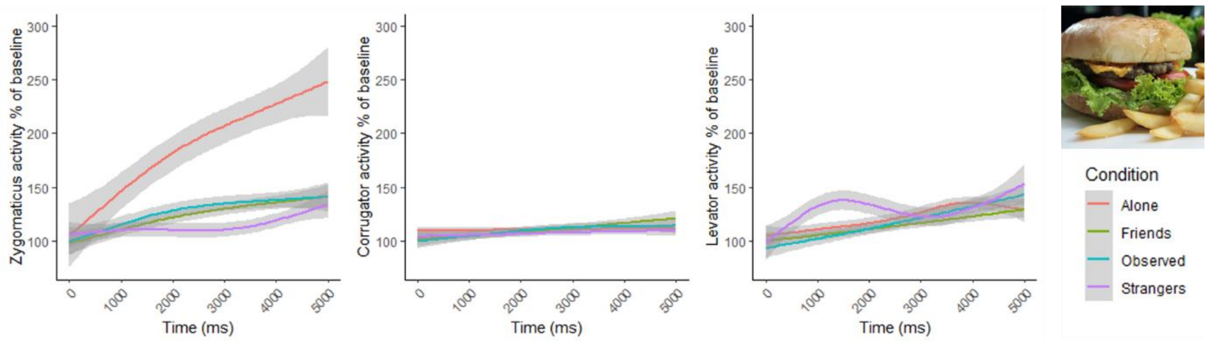


Figure 11. Facial muscle activity time series plot for pizza and burger by social condition.

The mean liking rating for pizza was 75.59 and did not differ between conditions (F(3, 140) = 1.31, p = 0.27, η^2 = 0.03). The mean liking rating for burger was 71.14 and did not differ between conditions (F(3, 130) = 1.96, p = 0.12, η^2 = 0.04). Participants in all conditions liked these food images equally but only those who participated alone expressed this liking using their facial muscles. This suggests that individuals are motivated to manage others' impressions of our food preferences by suppressing positive facial displays to unhealthy fast food.

That being said, the social context effects for other food images were not so clear. Consider the time series plot for ice cream in Figure 12.

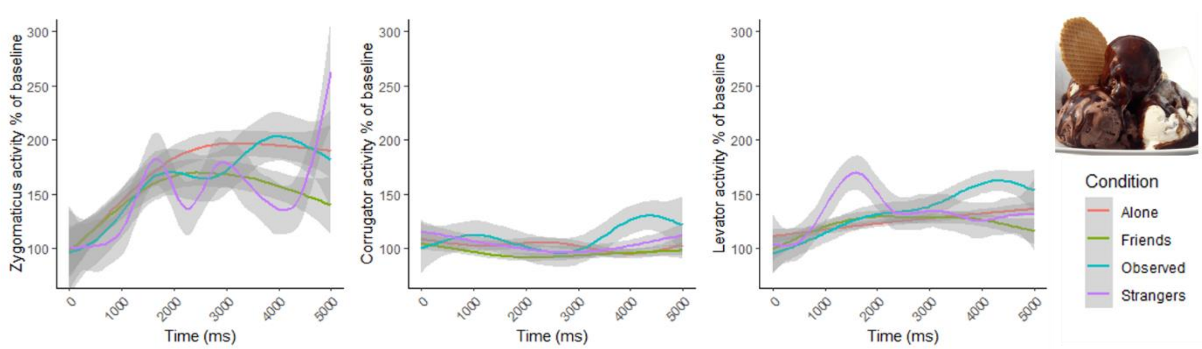


Figure 12. Facial muscle activity time series plot for ice cream by social condition.

The mean liking rating for ice cream was 80.13 and did differ between conditions (F(3, 145) = 4.06, p = 0.01, η^2 = 0.08). Post hoc comparisons using a Tukey HSD test indicated that mean liking in the Observed condition was higher than in the Alone condition (M_{Diff} = 8.64, 95% CI

[0.06, 17.23], $p = 0.05$) and in the Strangers condition ($M_{Diff} = 13.70$, 95% CI [2.67, 24.74], $p = 0.01$). However, this difference in subjective liking was not reflected by statistically significant differences in muscle activity. It has been shown that enjoyment smiles are smoother and more consistent in duration compared to non-enjoyment smiles (Ekman, Freisen, & Ancoli, 1980; Ekman & Friesen, 1982; Frank et al., 1993). This could account for the smoother progression of zygomaticus activity in the Alone and Friends conditions compared to the Observed and Strangers conditions.

These plots highlight the complex relationship between social context and facial affective responses. Positive expressions to food may be subject to social affiliation and impression management goals, but further confirmatory research is needed to better understand these effects.

5.4.4 Limitations and conclusions

The main limiting factor in these analyses lie in the calculations of rise to peak and return to baseline. As shown in Figure 8, the calculation for rise to peak was based on muscle activity at the start of the trial instead of at the start of the affective response. As such, our values for rise to peak are inseparable from individual variations in cognitive processes such as attention and visual perception. Promising avenues to tackle this issue include the use of regime switching (Yang & Chow, 2010) or autoregressive moving average models (Hamaker, Ceulemans, Grasman, & Tuerlinckx, 2015). With the calculation for return to baseline (Figure 9), we encounter a different shortcoming. For some participants and some trials, the emotion response was so large that it did not return to baseline levels within the five seconds of the trial. This means that our data may have been skewed towards faster returns to baseline. In an fMRI study on emotion regulation strategies, Goldin, McRae, Ramel, and Gross (2008) found that reappraisal strategies resulted in PFC activation within 5 seconds of stimuli presentation but suppression strategies resulted in PFC activation 10 to 15 seconds into the trial. If participants in our sample used emotion suppression strategies, we may have to examine longer time periods to achieve greater validity of our return to baseline calculations.

Another limitation with our data was that muscle activity baselines and maximum contractions were measured within the social context manipulations. Given that the data used in the analyses were changescores from baseline as a percentage of maximum contractions, our results may not have captured the totality of the social context effects. For example, zygomaticus maximum contractions were smaller in the Friends condition compared to the Alone and Observed conditions, perhaps resulting in larger changescores for zygomaticus activity in the Friends condition. Future studies should have participants' muscle activity baselines and maximum contractions measured separately from the main experimental session and within a consistent social environment.

Overall, these results suggest that social context does influence the temporal dynamics of facial affective responses, where the presence of a co-acting stranger may speed up negative expression generation, and where expression regulation appears to be dependent on both the valence of the emotional stimuli and the social environment. An investigation into the temporal patterns of positive facial responses hint that the social context effects observed in our research may be, in part, driven by affiliative and impression management goals. These findings are exploratory and not without limitations, but they do hint at a compelling new area of emotion research.

6 Temporal dynamics of facial affective responses: insights into consumer preference

The exploratory findings in this thesis chapter is based on the datasets from Chapters 2 and 3 which have already been published. As such, there is no intention to submit this chapter for publication.

6.1 Introduction

The trend of using emotion measurement in consumer and sensory science has provided a wealth of new insights into consumer preference and behaviour. The majority of consumer emotion studies have made use of self-report, subjective ratings and questionnaires that regard emotion as a discrete, static phenomena (Kaneko et al., 2018; Lagast et al., 2017). While this conceptualisation of emotion has advanced our understanding of the consumption experience, it is far removed from the dynamic flow of emotional information that we produce and receive in our everyday interactions with products and people. Fortunately, there is a small but growing movement within the field towards a more ecologically valid appreciation of emotion as a dynamic process that unfolds over time.

The earliest studies to consider the temporal dynamics of consumption emotions did so by measuring self-reported emotion at different time points during the consumption experience. Hormes and Rozin (2011) measured positive and negative affect using the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988) before, during and 30 minutes after chocolate consumption. Schifferstein, Fenko, Desmet, Labbe, and Martin (2013) measured consumers' emotional experience of dehydrated food using 12 emotions words and their corresponding cartoons from the PrEmo instrument (Desmet, 2003) at 5 stages – choosing the product in the supermarket; opening the package; preparing the food; eating the food; and re-purchasing. And King, Meiselman, and Carr (2013) used EsSense Profile (King & Meiselman, 2010) to evaluate the impact of the number of samples on changes in emotional intensity.

Discerning the need for a standardised methodology, Jager and colleagues (2014) introduced the Temporal Dominance of Emotion (TDE) method. TDE was adapted from the Temporal Dominance of Sensation (TDS) methodology (Pineau, Cordelle, & Schlich, 2003; Pineau et al., 2009) used to evaluate the temporal unfolding of sensory attributes over time. TDS and TDE involve presenting participants with a list of sensation or emotion words on a computer screen. The participant is tasked with selecting whichever attributes they perceive as the most dominant during the course of engaging with the sample. The result is a temporal dominance curve such as in Figure 13 below.

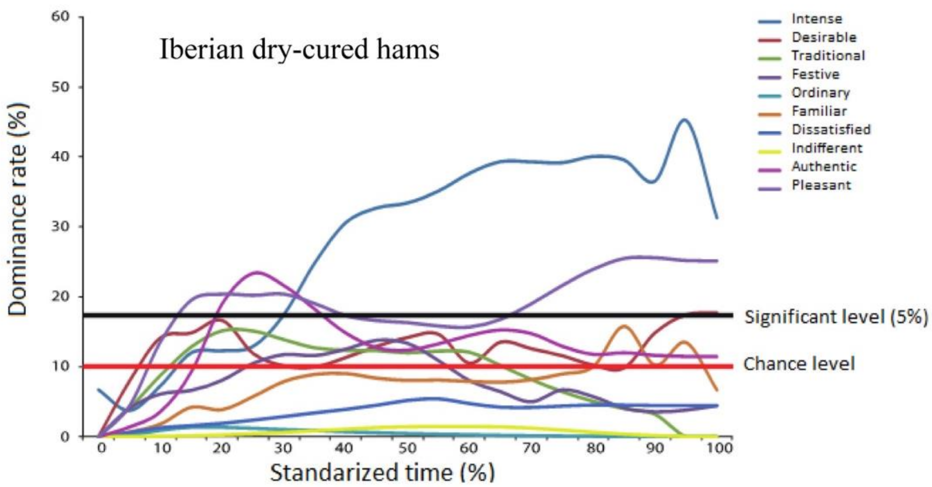


Figure 13. Average TDE curves for Iberian dry-cured hams. Adapted with permission from "Emotional responses to the consumption of dry-cured hams by Spanish consumers: A temporal approach" by L. Lorido, E. Pizzaro, M. Estévez and S. Ventanas, 2019, Meat Science, 149, p. 126-133. Copyright 2019 by Elsevier Ltd.

The authors of the above study employed both TDS and TDE and were able to identify the sensory attributes of ham that contributed to positive emotion and liking ratings. TDE has also been used to evaluate the effect of packaging colour on hamburgers (Merlo et al., 2019), the effect of adding hop aroma to beer (Silva et al., 2019), and emotional responses to TV advertisements (Peltier, Visalli, & Thomas, 2019). These studies are in agreement that TDE allows for a richer understanding of a product's emotional profile.

As with any methodology, TDE is not without its limitations. The developers of TDE (Jager et al., 2014) note that on average, the number of emotion attributes selected per trial is lower than the number of sensory attributes selected. They speculate that emotional associations may be less available to our conscious awareness compared to sensory product characteristics, making it more difficult for us to report on them. To access this deeper, more intuitive and automatic level of the emotional response, we would have to rely on implicit emotion measurement tools, such as facial expression analysis.

To date, a handful of studies have investigated the temporal dynamics of facial expression to consumer products. One study on the acceptance of insect-based products analysed the duration of positive and negative facial expression (Le Goff & Delarue, 2017) while two others compared expression intensity between different time points in the consumption episode (Kostyra et al., 2016; Rocha-Parra, García-Burgos, Munsch, Chirife, & Zamora, 2016). Most recently, a research team in Portugal proposed a new data analysis procedure – the Temporal Dominance of Facial Emotions (TDFE), based on TDS/TDE methodology to evaluate temporal facial expression data from automated facial expression recognition programs like FaceReader (Den Uyl & Van Kuilenburg, 2005). They applied this procedure to evaluate five samples of herbal infusions and their results are displayed in the TDFE curves below.

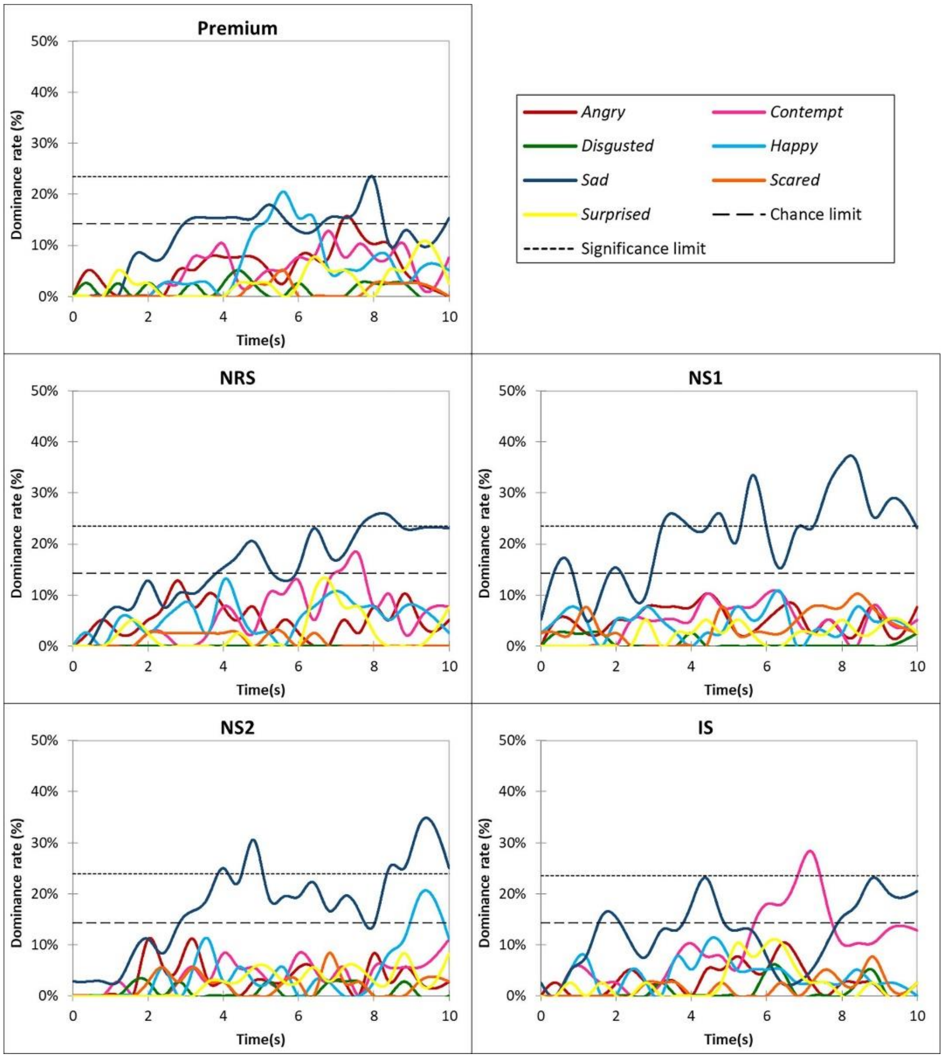


Figure 14. TDFE curves for 5 samples of lemon verbena infusions. Reprinted with permission from “Implicit evaluation of the emotional response to premium organic herbal infusions through a temporal dominance approach: Development of the temporal dominance of facial emotions (TDFE)” by C. Rocha, R.C. Lima, A.P. Moura, T. Costa and L.M Cunha, 2019, Food Quality and Preference, 76, p. 71-80. Copyright 2019 by Elsevier Ltd.

As can be seen in Figure 14, the study found that the only facial emotions that achieved a significant dominance rate were “sad” and “contempt”. This finding is concordant with other studies demonstrating that facial responses are better indicators of disliking rather than liking (Danner et al., 2014; Horio, 2003; Wendin et al., 2011; Zeinstra et al., 2009; Zhi et al., 2018).

The authors conclude that the value of the TDFE methodology lies in its ability to characterise the emotional response over the full consumption period without interrupting participants to ask for their explicit evaluations. Concurrently, but unbeknownst to each other, a research team in France (Mahieu, Visalli, Schlich, & Thomas, 2019) developed a similar temporal facial analysis methodology using Microsoft Azure Face API © on videos recorded by participants in their own homes. Their method was able to discriminate video advertisements and perfumes, but not samples of chocolate.

The use of video facial expression coding and analysis programs such as FaceReader and Microsoft Azure Face API encounter two shortcomings in food product testing scenarios. Firstly, they are unable to accurately detect facial displays when the participant turns away from the camera, or when their face is partially obscured. This is a common occurrence during food product testing when participants have to look down at their samples or when their hand is raised in front of their mouths to eat the sample. Secondly, they are restricted to reporting on facial displays that reach the threshold for visual perception. Microexpressions or facial muscle activity that does not result in an identifiable expression go undetected. These limitations are circumvented in facial electromyography (EMG) as facial muscle activation is measured via highly sensitive electrodes placed directly on the surface of the face. While facial EMG is limited in its own way, it may be able to offer insights on consumer preference and behaviour that are missed by video facial expression analysis programs.

The present chapter aims to contribute to this budding phase of temporal emotion research in consumer and sensory science by exploring the dynamics of facial muscle activity as measured with facial EMG. It will discuss the temporal variables, rise to peak and return to baseline, and their relationship with subjective liking, and comment on individual differences in facial expressivity.

6.2 Methods

Given that the same stimuli and experimental procedures were used in the experiments presented in chapters 3 and 4, the data from both studies were combined and analysed as one dataset in this chapter. For a detailed description of the stimuli, measures, procedure and data processing, please refer to the methods sections in chapters 3 and 4.

6.2.1 Participants

The data from 157 participants, 70 in study 1 and 87 in study 2, were used in the following analyses. Participants (108 female, 49 male) were aged between 18 and 74 (M = 28.0, SD = 10.3) and were primarily of Asian and NZ European descent.

6.2.2 Design

Participants in study 1 were randomly assigned to one of two experimental conditions – alone or observed. Participants in the alone condition were directed to sit in front of a computer screen in a sound-attenuated testing booth while participants in the observed condition were directed to sit in front of a computer screen beside the experimenter in the main lab. Participants in study 2 were randomly assigned to one of three experimental conditions: Alone, Friends or Strangers. Participants in the Alone condition sat the experiment with no other participants in the testing booth; those in the Friends condition participated with a friend or family member of their own choosing; and those in the Strangers condition were randomly paired with another participant also assigned to that condition. A breakdown of the number of participants in each condition is shown in table 4.

Table 4

Number of participants in each condition.

	Study 1		Study 2		
	Alone	Observed	Alone	Friends	Strangers
n	30	30	31	31	25

Participants' fixation and maximum voluntary contractions were comparable between the alone conditions of both studies, and comparable across all four conditions. These analyses are included in Appendix A.

6.2.3 Data analysis

A maximum likelihood estimation approach was used throughout to compare models using a chi square test on model likelihood. Satterthwaite approximations to degrees of freedom were used in all linear mixed model t-tests. Confidence intervals for fixed effects were calculated using parametric bootstrapping based on 10,000 simulations of the fitted models. The 2.5% and 97.5% percentiles were extracted to give an estimate of the 95% confidence level for each effect. Standardised effects and confidence intervals are reported in the supplementary materials. An alpha level of $\alpha = 0.05$ was used for all analyses.

6.3 Results and discussion

6.3.1 Temporal variables of facial muscle activity

We were interested to know if temporal variables of facial muscle activity afforded greater insights into consumer liking and preference. To investigate this, two models were specified for each variable. The first model was a null model with LAM (subjective liking) as the dependent variable, and participant and food image as random intercepts. The second model added muscle activity as predictors. The lmer specification for the models is presented below. These models were run with mean muscle activity (across the whole trial), peak muscle activity, speed of rise to peak, and speed of return to baseline for each muscle.

$$\text{LAM} \sim 1 + (1|\text{participant}) + (1|\text{food image}) \tag{1}$$

$$\text{LAM} \sim \text{zygomaticus} + \text{corrugator} + \text{levator} + (1|\text{participant}) + (1|\text{food image}) \tag{2}$$

As presented in table 1, the variables rise to peak and return to baseline were not more predictive of subjective liking compared to mean or peak values for muscle activity. Peak muscle activity had the strongest relationship with subjective liking, with a one standard deviation increase in peak zygomaticus, corrugator and levator activity predicting a 2.1-point increase, a 2.3-point decrease, and a 1.4-point decrease in subjective liking respectively. Please refer to Appendix A for full model estimates and 95% confidence intervals.

Table 5

Fixed effects of standardised mean, peak, rise to peak and return to baseline muscle activity for models predicting subjective liking on a 0-100 scale.

	Zygomaticus	Corrugator	Levator
Standardised mean muscle activity	1.39*	-1.61*	-1.08*
Standardised peak muscle activity	2.10*	-2.29*	-1.43*
Standardised rise to peak	1.14*	-1.49*	-0.97*
Standardised return to baseline	0.64	-1.20*	-0.35

Note: * $p<0.01$

These analyses suggest that these temporal variables of facial responses are not as closely related to subjective liking as mean and peak muscle activity. Rise to peak might be more associated with the level of arousal or familiarity elicited by food stimuli and return to baseline might have stronger correlations with regulatory consumption behaviours. Further research is needed to investigate these potential relationships.

There are two possible explanations for the finding that peak muscle activity is more closely related to subjective liking than mean muscle activity. In the first case, the peak value for each trial might represent rapid, involuntary microexpressions (e.g. Fig 15a), not perceivable by the human eye. This would suggest that implicit facial emotional responses are correlated to explicit subjective liking ratings. On the other hand, peak muscle activity might be situated within larger, voluntary expressions (e.g. Fig 15b), visible to observers. This would suggest that social-communicative facial displays correspond to explicit subjective liking ratings.

(a) (b)

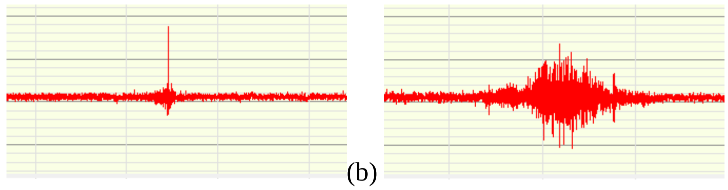


Figure 15. Raw zygomaticus major muscle activity screen captures from Biopac Acqknowledge 4.2 EMG recording software. Each panel displays muscle activity over a time period of approximately 5 seconds.

To investigate this further, future research should use both facial EMG and automated facial expression analysis to determine which type of facial response is more predictive of subjective liking.

6.3.2 Temporal progression of facial responses

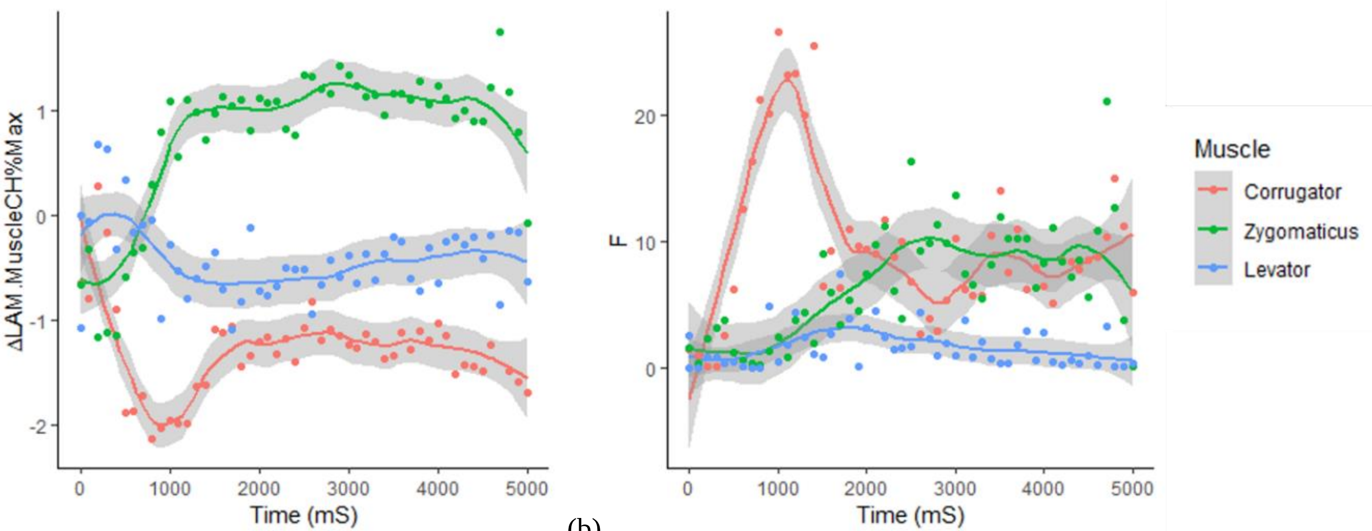
We were also interested to find out if the predictive ability of muscle activity varied over the time course of the presentation of food images. Models predicting liking were specified for mean muscle activity for each second of the trial and the fixed effect (Table 6) and the fixed effects beta coefficients and the fixed effects ANOVA F coefficients over time in 100ms intervals were plotted in Figure 16 below. The smoothed lines represent loess lines fitted to the individual model coefficients.

Table 6

Fixed effects of mean muscle activity over each second of the trial for models predicting LAM.

	Zygomaticus	Corrugator	Levator
0-5000 ms	1.39*	-1.61*	-1.08*
0-1000 ms	0.05	-1.40*	-0.27
1000-2000 ms	1.28*	-1.68*	-1.35*
2000-3000 ms	1.36*	-1.47*	-1.08*
3000-4000 ms	1.38*	-1.22*	-0.91*
4000-5000 ms	1.34*	-1.00*	-0.74

Note: * $p<0.01$



(a) (b)

Figure 16. (a) Fixed effects beta coefficients for each muscle over time. (b) Fixed effects ANOVA F coefficients for each muscle over time.

Table 6 and Figure 16 both show that zygomaticus has the strongest relationship with liking between 2 and 4 seconds after the start of the trial, while corrugator and levator have the strongest relationship with liking between 1 and 2 seconds after the start of the trial. These findings are in line with a study on facial expressions in response to food odours. He et al. (2014) measured facial expressions using a facial expression recognition software and found that expressions of disgust and anger differentiated odours at 180ms and 500ms respectively, while happy expressions only differentiated odours from 1780ms onwards. He and colleagues proposed that the earlier onset of negative expressions reflect an automatic central nervous system response to environmental threats, whereas the later onset of positive expressions may be driven by slower cognitive processing of pleasantness/unpleasantness.

6.3.3 Stimuli discrimination

In the following plots, the y-axis represents muscle activity as a percentage of baseline activity for that trial and the x-axis is the time in milliseconds. The grey bands represent the 95% confidence intervals for the loess smoothed conditional means.

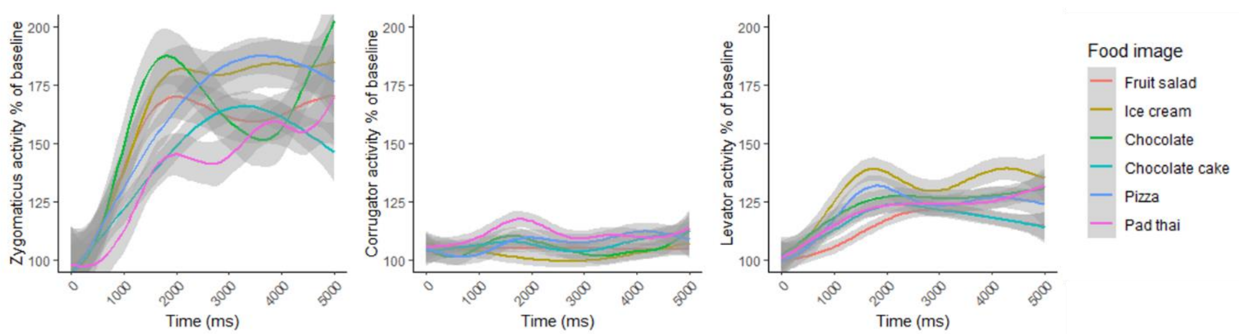


Figure 17. Facial muscle activity time series plots for the six food images with the highest LAM ratings.

From Figure 17, it appears that the speed of zygomaticus response for fruit salad, ice cream and chocolate may be marginally greater than that for chocolate cake, pizza and pad thai. However, the differences in zygomaticus speed of rise to peak are not large enough to reliably discriminate between these highly liked food images (F(5, 828) = 0.389, $p = 0.86$, $\eta^2 = 0.002$).

Previous studies have concluded that smiling facial muscle activity and expressions are not as expedient as explicit emotion measures at discriminating between similar samples. Our results suggest that temporal variables of smiling muscle activity may not fare much better.

6.3.4 Individual differences in facial response dynamics

For some participants, the pattern of zygomaticus response differentiated between similarly rated food images, and for others, it did not. Consider the time series plots for participants 29 and 65 below (Figure 18 and Figure 19, respectively). Note the difference in y-axis between the participants.

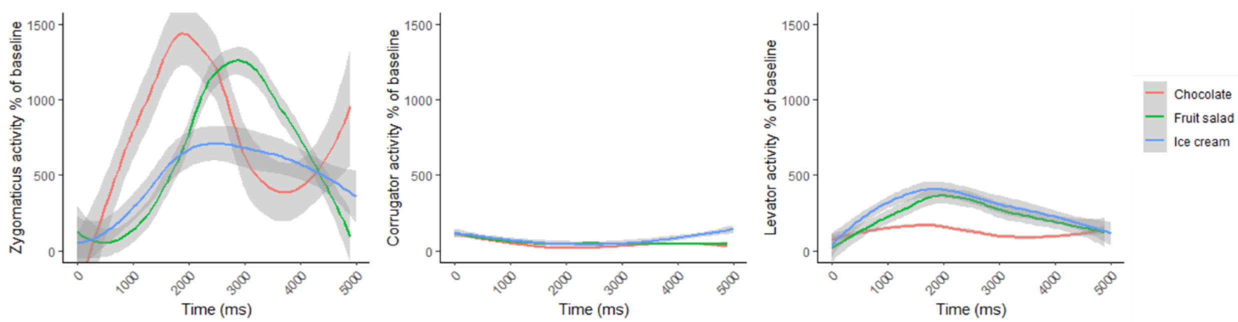


Figure 18. Facial muscle activity time series plot for participant 29 in the Strangers condition.

For participant 29, chocolate (LAM = 100), fruit salad (LAM = 100) and ice cream (LAM = 100) were their top 3 highest rated food images.

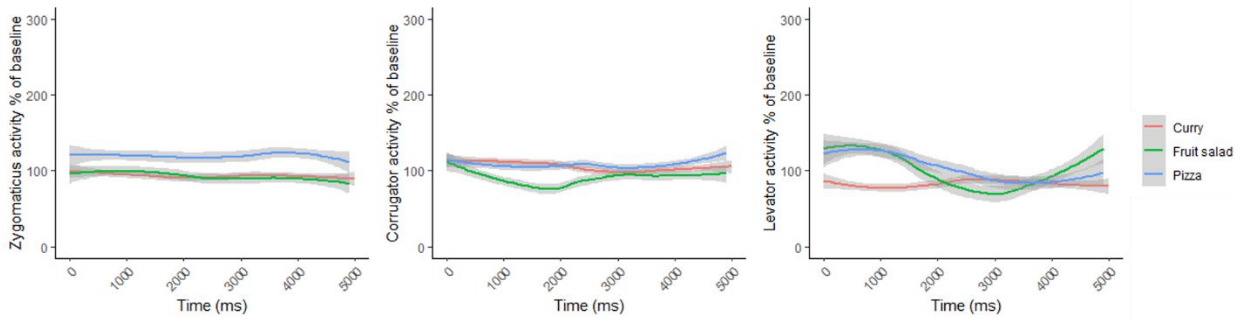


Figure 19. Facial muscle activity time series plot for participant 65 in the Strangers condition.

For participant 65, curry (LAM = 97.0), fruit salad (LAM = 97.3) and pizza (LAM = 96.8) were their top 3 highest rated food images.

Given these large individual differences between participants it is not surprising that we found small relationships between subjective liking and facial muscle activity. Studies have shown that participants' BMI and hunger vs. satiety levels influence facial responses to food images (Hoefling et al., 2009; Soussignan et al., 2019). Factors such as sleep-deprivation (Minkel, Htaik, Banks, & Dinges, 2011), and medical conditions such as Parkinson’s disease (Ricciardi et al., 2015; Spielman, Borod, & Ramig, 2003) and schizophrenia (Earnst et al., 1996; Trémeau et al., 2005) are also known to influence facial expressivity. Future studies that make use of facial response measures should screen participants accordingly and take BMI and hunger into account.

6.4 Conclusion

In this chapter, the relationship between temporal variables of facial affective responses and subjective liking was investigated. Analyses revealed that mean and peak muscle activity had a stronger relationship with subjective liking which might indicate that temporal variables are capturing some yet unknown aspects of the consumption experience. The large individual differences in facial responsiveness revealed by the data warrant also further investigation given the current popularity of facial emotion measures in consumer and sensory science.

7 General conclusions

The objective of this thesis was to investigate the influence of social context on food-evoked emotion. It focused on the subjective experience and expressive components of the wider emotional response during the visual perception and post-consumption evaluative phase of the consumption process.

The introduction reviewed the available literature on social context, emotion theory, and emotion measurement in consumer and sensory science, highlighting the significant gap in research informing our understanding of context effects on emotion, and consumption emotions in particular.

Chapter 2 set out to investigate the influence of three contextual factors – meal timing, location, and social setting, on the hedonic and emotional associations of recalled meals. In an online survey of 866 respondents from all over the world, it was found that social meals amplified positive emotion relative to solitary meals, work meals diminished positive emotion relative to meals eaten elsewhere and that meal timing did not have as much of an influence on emotional associations in comparison to meal location and sociality. These results highlighted the value of social eating, and the importance of deeper explorations into the effect of social context on food-evoked emotion.

Chapters 3 and 4 aimed to chip away at this task by looking into the effects of social context on the expressive component of emotion, specifically, facial muscle activity as measured via surface electromyography. In chapter 3, "An unfamiliar social presence reduces facial disgust responses to food stimuli", I reviewed research from psychology and consumer and sensory science which suggested that positive facial expressions are facilitated and negative expressions inhibited in the presence of others. An experiment was conducted in which participants' facial muscle activity was measured while they viewed food images either alone or in the presence of the experimenter. Results provided evidence that facial muscle activity indicative of disgust toward food images were inhibited in the presence of the experimenter. Given that consumer sensory and emotion evaluations are typically carried out in the presence of the researcher or a research assistant, this study underscored the need for more research exploring this effect with commonly employed emotion measurement methods.

Chapter 4, "Co-acting strangers but not friends influence subjective liking and facial affective responses to food stimuli", built on the findings of chapter 3 by considering the relationship between the expresser and the audience on intensity of facial displays. An experiment was conducted in which participants' facial muscle activity was measured while they viewed food images either alone, with a co-acting friend, or with a co-acting stranger. The reviewed literature indicated that the presence of friends amplifies positive and reduces negative facial displays, while strangers inhibit both positive and negative displays. In contrast, my results revealed that facial affective responses to food stimuli was facilitated by the presence of a co-acting stranger, but not by a co-acting friend. Furthermore, facial muscle activity aligned most with subjective liking ratings in the presence of a co-acting stranger. These findings were discussed in relation to social norms and the Behavioural Ecology View (BECV) of facial displays.

Chapters 5 and 6 took advantage of the less structured format of conventional thesis chapters to present exploratory analyses into the temporal dynamics of expressive emotion. Chapter 5 introduced the temporal variables, rise to peak and return to baseline, and discussed how they might be influenced by the social environment. Analyses suggested that expression generation was accelerated by the presence of a co-acting stranger, and that expression regulation was dependent on both the valence of the emotional stimuli and the social environment. I also presented evidence that temporal patterns of facial response may be primarily driven by how socially appropriate it is to express emotion in that context or not.

Chapter 6 explored how temporal patterns of facial affective responses might advance our understanding of consumer preference and behaviour. Analyses revealed that mean and peak measures of facial muscle activity were more strongly correlated with subjective liking compared to temporal measures. In chapter 6, I also touched on individual differences in facial responsiveness to liked food. Chapters 5 and 6, although exploratory, serve as a starting point for future researchers to build an understanding of the temporal dynamics of facial responses to food.

Taken together, the findings presented in this thesis provide evidence for the influence of social context on both explicit and implicit components of food-evoked emotion. It was shown that eating with close others might amplify our positive subjective emotional evaluations of a meal, although we may be less inclined to express this positivity during the experience itself. In the presence of unfamiliar others, the expression of food-evoked emotion was demonstrated to be dependent on the nature of the relationship between the expresser and their audience. Social context was also demonstrated to influence temporal variables of facial affective responses, however, this paled in comparison to large individual differences in patterns of expression. As a whole, this thesis contributed to our understanding of the influence of social context on the subjective experience and expressive components of food-evoked emotion. Given the subtlety and complexity of our findings, future research should build on these advances and also investigate social context effects on the other components of emotion – the cognitive, neurophysiological, and motivational. This thesis also focused on the visual perception and post-meal evaluative stages of the consumption process, however future researchers might want to examine other stages such as smelling, tasting, oral processing, or even stages from the broader consumption system such as recognition of need, evaluation of alternatives, and selection, among others. This thesis also scratched the surface of the temporal dynamics of facial affective responses to food. Emotion researchers have long recognized the importance of considering emotion as a dynamic process and the opportunities to expand the literature in this area are endless. The findings and ideas presented in this thesis represent a small but novel contribution to the emotion and consumer and sensory science disciplines.

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9 Appendix A: Supplementary Materials for Chapter 2

9.1 Proportional odds logistic regression tables

Table 7

Proportional odds logistic regression model estimates of odds ratios for EsSense25 emotion terms "active" to "enthusiastic". If the number in the cell is greater than one, the odds of that emotion term being used to describe that meal context category is greater than the odds of it being used to describe the comparison meal context category (the term contained in brackets). If the number in the cell is less than one, the reverse is true. The interpretation of the first 2 rows for active is as follows: For every 1 point increase in LAM, the odds of a more intense rating for "active" is 1.044 times more likely (or 4.4% more likely). For meals eaten with a family member or friend, the odds for a more intense rating for "active" is 1.456 times more likely (or 45.6% more likely).

	Active	Joyful	Adventurous	Loving	Aggressive	Mild	Bored	Nostalgic	Calm	Pleasant	Disgusted	Satisfied	Enthusiastic
LAM	1.044*	1.100*	1.041*	1.063*	0.986*	0.991*	0.945*	1.030*	1.036*	1.089*	0.930*	1.117*	1.077*
With family member or friend (-Alone)	1.456*	1.742*	1.220	2.358*	1.256	0.979	0.582*	1.253	0.905	1.496*	1.203	1.230	1.684*
With family members or friend group (-Alone)	1.501*	1.593*	1.072	2.226*	1.208	0.811	0.576*	1.265	0.834	1.442*	0.954	1.075	1.465*
With spouse/partner (-Alone)	1.271	1.704*	1.144	4.225*	1.044	0.839	0.599*	0.843	1.329	1.823*	1.010	1.384	1.343
With family member or friend (-With spouse/partner)	1.146	1.022	1.067	0.558*	1.203	1.167	0.972	1.486	0.681	0.821	1.190	0.889	1.254
With family members or friend group (-With spouse/partner)	1.182	0.935	0.937	0.527*	1.157	0.967	0.962	1.501*	0.627*	0.791	0.944	0.777	1.091
With family member or friend (-With family members or friend group)	0.970	1.093	1.139	1.059	1.040	1.207	1.010	0.990	1.086	1.038	1.261	1.144	1.149
Brunch (-Breakfast)	0.857	1.094	1.120	0.984	0.585	0.888	0.610	1.020	1.072	0.959	1.773	0.900	1.121
Lunch (-Breakfast)	0.881	1.024	1.136	0.901	0.857	0.977	0.921	1.123	1.005	0.878	1.257	0.878	0.977
Dinner (-Breakfast)	0.646*	1.053	1.353	1.057	0.784	0.772	0.752	0.981	0.619*	0.709*	1.596	0.888	0.957
Brunch (-Dinner)	1.325	1.038	0.827	0.931	0.746	1.151	0.811	1.040	1.730	1.353	1.111	1.013	1.171
Lunch (-Dinner)	1.362*	0.972	0.839	0.852	1.094	1.265	1.224	1.145	1.622*	1.238	0.788	0.989	1.021
Brunch (-Lunch)	0.973	1.068	0.986	1.093	0.682	0.909	0.663	0.909	1.067	1.092	1.410	1.024	1.146
At the home of a family member or friend (-At home)	1.349	1.322	1.493	1.603*	1.113	0.957	0.778	1.292	0.837	1.481	1.577	0.973	1.186
At a dining establishment (-At home)	1.579*	1.312	1.987*	0.820	1.038	0.807	0.647*	0.897	0.717*	1.242	0.968	1.000	1.362
At work/school/university (-At home)	1.090	0.722	0.972	0.504*	0.862	0.982	1.394	0.608*	0.673*	0.733	0.848	0.773	0.831
At a dining establishment (-At the home of a family member or friend)	1.170	0.992	1.331	0.512*	0.932	0.843	0.831	0.694	0.857	0.839	0.614	1.029	1.149
At work/school/university (-At the home of a family member or friend)	0.808	0.546*	0.651	0.314*	0.774	1.025	1.792	0.471*	0.804	0.495*	0.538	0.795	0.701
At work/school/university (-At a dining establishment)	0.690	0.550*	0.489*	0.615*	0.831	1.217	2.155*	0.678	0.938	0.590*	0.876	0.773	0.610*
Male (-Female)	1.917*	1.287*	1.392*	1.006	2.665*	1.230	1.446*	1.395*	1.111	1.075	1.570*	1.105	0.994
25 to 34 (- 18 to 24)	1.018	0.868	0.719*	0.768	0.839	0.843	0.836	0.902	0.858	0.896	0.738	0.900	0.890
35 to 44 (- 18 to 24)	0.848	0.622*	0.815	0.825	0.952	0.928	0.771	0.700	0.835	0.678*	0.548	0.679*	0.723
45+ (- 18 to 24)	0.985	0.633*	0.809	0.843	0.709	0.886	0.443*	0.852	0.977	0.875	0.498	0.838	0.960
35 to 44 (- 25 to 34)	0.833	0.716	1.133	1.073	1.134	1.100	0.923	0.776	0.973	0.756	0.743	0.754	0.813
45+ (- 25 to 34)	0.967	0.730	1.124	1.098	0.844	1.051	0.530*	0.944	1.139	0.976	0.675	0.931	1.079
45 + (- 35 to 44)	1.161	1.019	0.992	1.023	0.744	0.955	0.575*	1.217	1.170	1.291	0.908	1.234	1.327

Note: *$p < 0.002$

Table 8

Proportional odds logistic regression model estimates of odds ratios for EsSense25 emotion terms "secure" to "interested". If the number in the cell is greater than one, the odds of that emotion term being used to describe that meal context category is greater than the odds of it being used to describe the comparison meal context category (the term contained in brackets). If the number in the cell is less than one, the reverse is true. The interpretation of the first row for guilty and worried is as follows: For every 1 point increase in LAM, the odds of a more intense rating for "guilty" is 1.018 (1/0.982) times less likely (or 1.8% less likely) and the odds of a more intense rating for "worried" is 1.022 (1/0.978) times less likely (or 2.2% less likely).

	Secure	Free	Tame	Good	Understanding	Goodnatured	Warm	Guilty	Wild	Happy	Worried	Interested
LAM	1.042*	1.048*	1.003	1.086*	1.036*	1.049*	1.057*	0.982*	1.022*	1.092*	0.978*	1.066*
With family member or friend (-Alone)	1.303	1.227	1.016	1.322	1.630*	1.759*	1.769*	0.840	1.050	1.797*	0.951	1.592*
With family members or friend group (-Alone)	1.489*	1.144	0.948	1.402*	1.442*	1.578*	1.596*	0.804	1.086	1.639*	0.832	1.518*
With spouse/partner (-Alone)	1.833*	1.199	1.212	1.716*	1.889*	1.706*	1.940*	0.786	0.923	2.111*	0.841	1.497*
With family member or friend (-With spouse/partner)	0.711	1.024	0.838	0.771	0.863	1.031	0.912	1.069	1.138	0.851	1.130	1.064
With family members or friend group (-With spouse/partner)	0.812	0.955	0.782	0.817	0.763	0.925	0.823	1.023	1.177	0.776	0.989	1.014
With family member or friend (-With family members or friend group)	0.875	1.073	1.072	0.943	1.130	1.114	1.109	1.044	0.967	1.096	1.143	1.049
Brunch (-Breakfast)	0.731	0.937	0.927	0.918	1.259	1.177	0.956	1.098	0.604	0.953	0.899	1.577
Lunch (-Breakfast)	0.883	1.117	0.929	0.947	1.101	0.925	1.073	1.417	1.045	0.983	0.991	1.167
Dinner (-Breakfast)	0.687*	0.853	0.809	0.667*	0.884	0.724*	0.999	1.542*	1.207	0.901	1.050	1.117
Brunch (-Dinner)	1.064	1.099	1.145	1.377	1.425	1.625	0.957	0.712	0.501	1.057	0.856	1.411
Lunch (-Dinner)	1.286	1.310	1.147	1.420*	1.246	1.277	1.073	0.919	0.866	1.091	0.944	1.045
Brunch (-Lunch)	0.827	0.839	0.998	0.970	1.144	1.272	0.892	0.775	0.578	0.969	0.907	1.351
At the home of a family member or friend (-At home)	1.155	1.122	0.998	1.333	1.170	1.430	1.430	1.058	1.753*	1.631	1.220	1.500
At a dining establishment (-At home)	0.728	1.110	0.829	1.008	0.927	1.003	0.832	2.021*	1.618*	1.259	1.518*	1.503*
At work/school/university (-At home)	0.578*	0.629*	0.858	0.712	0.763	0.836	0.708	0.734	1.015	0.691	0.977	0.896
At a dining establishment (-At the home of a family member or friend)	0.631	0.989	0.831	0.756	0.792	0.701	0.582*	1.910*	0.923	0.772	1.245	1.002
At work/school/university (-At the home of a family member or friend)	0.501*	0.561*	0.860	0.534*	0.652	0.585	0.495*	0.694	0.579	0.423*	0.801	0.597
At work/school/university (-At a dining establishment)	0.794	0.567*	1.035	0.706	0.823	0.834	0.852	0.363*	0.627	0.549*	0.644	0.596*
Male (-Female)	1.077	1.548*	1.394*	1.253	1.210	1.047	0.987	1.091	1.975*	1.144	1.015	1.337*
25 to 34 (- 18 to 24)	0.886	0.946	0.734*	0.922	0.848	1.094	0.980	0.922	0.756	0.835	0.797	0.878
35 to 44 (- 18 to 24)	0.907	0.843	0.649*	0.717	1.003	1.079	0.794	0.654	0.615*	0.700	0.680	0.930
45+ (- 18 to 24)	1.060	1.326	0.581*	0.877	1.205	1.392	1.124	0.395*	0.526	0.921	0.613*	1.108
35 to 44 (- 25 to 34)	1.024	0.891	0.884	0.778	1.183	0.986	0.810	0.709	0.814	0.838	0.854	1.060
45+ (- 25 to 34)	1.196	1.401	0.792	0.951	1.420	1.273	1.147	0.429*	0.696	1.102	0.770	1.263
45 + (- 35 to 44)	1.168	1.573	0.895	1.222	1.201	1.291	1.415	0.605	0.855	1.315	0.901	1.191

Note: *$p < 0.002$

9.2 The survey

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Participant Information

What is this study about?

In this survey, you will be asked to recall three meals you've had in the past week and then rate the emotions you associated with those meals. Upon completion, you will be able to see a summary of your emotional associations compared to others who have taken part in this study.

The survey should take no more than 10 – 15 minutes of your time and will aid in our understanding of food-evoked emotion. This study aims to build on the existing literature on sensory and hedonic evaluations by investigating emotional evaluations of every day meals.

By clicking the **Start** button, you are agreeing to the following:

I am over 18 years of age.

I agree to participate in this study under the conditions set out below.

Start

What are your rights?

You are under no obligation to accept this invitation to take part in this study. If you decide to participate, you have the right to:

- decline to answer any particular question;

- withdraw from the study at any time during participation;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded.

How will your data be managed and stored?

All contributing data will be filed under a unique code and will be kept secure and strictly confidential. An anonymous version of the results from this project may be published or presented at conferences or seminars, published in academic journals, or disseminated by Massey University.

Project Contacts

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This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director, Research Ethics, telephone 06 356 9099 extn 86015, email: humanethics@massey.ac.nz

---

Age:

☐ Under 18

☐ 18 - 24

☐ 25 - 34

☐ 35 - 44

☐ 45 - 54

☐ 55 - 64

☐ 65 - 74

☐ 75 - 84

☐ 85 or older

☐ Prefer not to say

Next

Gender:

☐ Male

☐ Female

☐ Other

☐ Prefer not to say

Next

Country:

☐ USA

☐ Mexico

☐ Canada

☐ New Zealand

☐ Australia

☐ India

☐ Pakistan

☐ Bangladesh

☐ Thailand

☐ Philippines

☐ Malaysia

☐ Singapore

☐ China

☐ UK

☐ Ireland

☐ Netherlands

☐ Germany

☐ Italy

☐ France

☐ South Africa

☐ Prefer not to say

☐ Other (please specify below)

[ ]

[Next]

Please recall 3 meals you've had in the past week. Try to think of a variety of meals (e.g. Some breakfast, some lunch, some dinner; some at home, some at a dining establishment; some alone, some with others etc.)

Meal 1

Food and Drink: [ ]

Meal Time:

☐ Breakfast

☐ Brunch

☐ Lunch

☐ Dinner

Location:

☐ At home

☐ At the home of a family member or friend

☐ At work/school/university

☐ At a dining establishment (e.g. restaurant, cafe, food court)

☐ Outdoors

☐ In the car

☐ Other (please specify below)

[ ]

Social Setting:

☐ Alone

☐ With spouse/partner

☐ With family member or friend

☐ With family members or friend group

☐ With an acquaintance or someone you just met

☐ Other (please specify below)

____

How much did you like the meal?

Next

Take a moment to immerse yourself in the experience of the following meal; recall the sights, smells, sounds and tastes:

Foods: **Meal:** **Location:** **Setting:**

Please rate how strongly you felt each emotion listed below from 0 to 4 where:

0. Not at all
1. Slightly
2. Moderately
3. Very
4. Extremely

Active

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Joyful

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Adventurous

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Loving

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Aggressive

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Mild

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Bored

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Nostalgic

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Calm

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Pleasant

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Disgusted

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Satisfied

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Enthusiastic

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Secure

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Free

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Tame

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Good

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Understanding

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Good natured

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Warm

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Guilty

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Wild

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Happy

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Worried

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Interested

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

Next

10 Appendix B: Supplementary Materials for Chapter 3

10.1 Food images

Balut

Burger

Chocolate cake

Chicken feet

Chocolate

Crickets

Curry

Eggs on toast

Escargot


Fish and chips


Fried rice


Fruit


Fried guinea pig


Ice cream


Lamington


Mice heads


Pad thai noodles


Pasta

Pavlova

Pizza

Salad

Sandwich

Sannakji

Shirako

Soup

Steak pie

Sushi

Svið

Tarantulas

Weetbix

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Supreme pizza by Scott Bauer is in the public domain under Creative Commons CC0.

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Squares of milk chocolate from a candy bar by freefoodphotos.com is licensed under a Creative Commons Attribution 3.0 Unported License.

Indian food by freefoodphotos.com is licensed under a Creative Commons Attribution 3.0 Unported License.

Fried fish and chips by freefoodphotos.com is licensed under a Creative Commons Attribution 3.0 Unported License.

Meringue dessert with kiwi and strawberries by freefoodphotos.com is licensed under a Creative Commons Attribution 3.0 Unported License.

Fresh white bread sandwich on a plate by freefoodphotos.com is licensed under a Creative Commons Attribution 3.0 Unported License.

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Sliced cake on a plate by Abhinav Goswami is licensed under the Pexels License - https://www.pexels.com/photo-license/

Chicken feet by Buenosia Carol is licensed under the Pexels License - https://www.pexels.com/photo-license/

Pasta with Sauce in the Plate by Daniel Lindstrom is licensed under the Pexels License - https://www.pexels.com/photo-license/

Eggs on toast is in the public domain under Creative Commons CC0.

Pad thai is in the public domain under Creative Commons CC0.

Escargot à la Bourguignonne @The Boundary by flickr user eatingeast is licensed under a Creative Commons Attribution 2.0 Generic License.

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10.2 LMM statistical notation and lmer specification

The first model is a null model with participant and food image as random intercepts, allowing for between subjects and between stimuli variation in muscle activation. In the following equations, *i* represents the participant and *j* represents the food image.

$$Y_{ij} = \beta_0 + I_{0i} + J_{0j} + e_{ij}, I_{0i} \sim N(0, {\tau_{00}}^2), J_{0j} \sim N(0, {\omega_{00}}^2), e_{ij} \sim N(0, \sigma^2)$$

muscle ~ 1 + (1|participant) + (1|food image)

The second model includes LAM ratings as a continuous fixed effect.

$$Y_{ij} = \beta_0 + I_{0i} + J_{0j} + \beta_1 X_{1ij} + e_{ij}, I_{0i} \sim N(0, {\tau_{00}}^2), J_{0j} \sim N(0, {\omega_{00}}^2), e_{ij} \sim N(0, \sigma^2)$$

muscle ~ LAM + (1|participant) + (1|food image)

The third and final model builds on the second by including social condition as a categorical fixed effect.

$$Y_{ij} = \beta_0 + I_{0i} + J_{0j} + \beta_1 X_{1ij} + \beta_2 X_{2ij} + e_{ij}, I_{0i} \sim N(0, {\tau_{00}}^2), J_{0j} \sim N(0, {\omega_{00}}^2), e_{ij} \sim N(0, \sigma^2)$$

muscle ~ Social condition + LAM + (1|participant) + (1|food image)

10.3 LMM intraclass correlation coefficients

Table 9

Intraclass correlation coefficients for participant and food image in null models.

LMM DV	ICC (participant)	ICC (food image)
Zygomaticus activity	0.26	0.01
Corrugator activity	0.08	0.11
Levator activity	0.22	0.04

10.4 LMM fixed and random effects estimates

Table 10

Fixed effects and 95% confidence intervals for models predicting standardised zygomaticus major activity. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Zygomaticus Activity		
	(1)	(2)	(3)
LAM (z-score)		0.04***	0.04***
		(0.01, 0.06)	(0.01, 0.06)
Condition: Observed			-0.05
			(-0.17, 0.07)
Constant	0.06**	0.06*	0.09**
	(0.01, 0.13)	(-0.01, 0.13)	(0.01, 0.18)
Observations	1,764	1,764	1,764
Log Likelihood	-993	-990	-989
Akaike Inf. Crit.	1,993	1,989	1,990
Bayesian Inf. Crit.	2,015	2,016	2,023
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 11

Fixed effects and 95% confidence intervals for models predicting standardised corrugator supercilii activity. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Corrugator Activity		
	(1)	(2)	(3)
LAM (z-score)		-0.18***	-0.18***
		(-0.23, -0.14)	(-0.23, -0.14)
Condition: Observed			0.05
			(-0.06, 0.17)
Constant	0.03	0.03	0.01
	(-0.07, 0.14)	(-0.04, 0.10)	(-0.08, 0.10)
Observations	1,764	1,764	1,764
Log Likelihood	-1,770	-1,748	-1,747
Akaike Inf. Crit.	3,548	3,505	3,507
Bayesian Inf. Crit.	3,570	3,533	3,539

Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 12

Fixed effects and 95% confidence intervals for models predicting standardised levator labii superioris activity. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Levator Activity		
	(1)	(2)	(3)
LAM (z-score)		-0.10^{***}	-0.10^{***}
		(-0.12, -0.07)	(-0.12, -0.07)
Condition: Observed			-0.14^{**}
			(-0.26, -0.01)
Constant	0.05	0.05	0.12^{***}
	(-0.02, 0.13)	(-0.01, 0.12)	(0.03, 0.21)
Observations	1,764	1,764	1,764
Log Likelihood	-1,287	-1,273	-1,271
Akaike Inf. Crit.	2,582	2,555	2,553
Bayesian Inf. Crit.	2,604	2,583	2,586
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$		

10.5 T-test results

Table 13

Descriptive statistics of changescore muscle activity as a percentage of maximum contractions for each group.

	Alone		Observed	
Muscle	M	SD	M	SD
Zygomaticus	0.86	2.05	0.54	2.07
Corrugator	0.25	1.03	0.33	1.10
Levator	0.50	1.01	0.26	1.03

Table 14

Summary of descriptive statistics and t-test effect sizes for differences in muscle activity between groups.

	Alone	Observed

Muscle	n	M	SD	M	SD	t	d
Zygomaticus for liked foods	587	0.93	2.18	0.47	2.09	3.69***	0.21 (small)
Corrugator for disliked foods	274	0.70	1.38	0.47	1.40	-0.35	0.03 (negligible)
Levator for disliked foods	274	0.80	1.25	0.43	1.23	3.64***	0.30 (small)
Note:					*p<0.1; **p<0.05; ***p<0.01		

10.6 Rise time to peak LMM results

Table 15

Fixed effects and 95% confidence intervals for models predicting rise time to peak for corrugator supercilii. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Rise Time to Peak		
	(1)	(2)	(3)
Corrugator Activity		69.16***	67.32***
		(38.32, 100.02)	(36.71, 97.62)
Condition: Observed			178.26*
			(-3.79, 361.47)
Constant	2,340***	2,176***	2,091***
	(2,247, 2,433)	(2,056, 2,296)	(1,943, 2,239)
Observations	1,860	1,860	1,860
Log Likelihood	-16,262	-16,253	-16,251
Akaike Inf. Crit.	32,533	32,516	32,514
Bayesian Inf. Crit.	32,555	32,543	32,547
Note:	*p<0.1; **p<0.05; ***p<0.01		

11 Appendix C: Supplementary Materials for Chapter 4

11. 1 LMM statistical notation and lmer specification for facilitation and inhibition of facial muscle activity

The first model was a null model with participant and food image as random intercepts, allowing for between subjects and between stimuli variation in muscle activation. In the following equations, *i* represents the participant and *j* represents the food image.

$$Y_{ij} = \beta_0 + I_{0i} + J_{0j} + e_{ij}, I_{0i} \sim N(0, {\tau_{00}}^2), J_{0j} \sim N(0, {\omega_{00}}^2), e_{ij} \sim N(0, \sigma^2)$$

muscle ~ 1 + (1|participant) + (1|food image)

The second model included LAM ratings as a continuous fixed effect.

$$Y_{ij} = \beta_0 + I_{0i} + J_{0j} + \beta_1 X_{1ij} + e_{ij}, I_{0i} \sim N(0, {\tau_{00}}^2), J_{0j} \sim N(0, {\omega_{00}}^2), e_{ij} \sim N(0, \sigma^2)$$

muscle ~ LAM + (1|participant) + (1|food image)

The third and final model built on the second by including social condition as an interaction term.

$$Y_{ij} = \beta_0 + I_{0i} + J_{0j} + \beta_1 X_{1ij} + \beta_2 X_{2ij} + e_{ij}, I_{0i} \sim N(0, {\tau_{00}}^2), J_{0j} \sim N(0, {\omega_{00}}^2), e_{ij} \sim N(0, \sigma^2)$$

muscle ~ social condition * LAM + (1|participant) + (1|food image)

11.2 LMM intraclass correlation coefficients

Table 16

Intraclass correlation coefficients for participant and food image in null models.

LMM DV	ICC (participant)	ICC (food image)
Zygomaticus activity	0.21	0.01
Corrugator activity	0.20	0.09
Levator activity	0.29	0.03

11.3 LMM fixed and random effects estimates for mean muscle activity

Table 17

Fixed effects and 95% confidence intervals for models predicting mean zygomaticus major activity. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Standardised mean zygomaticus activity		
	(1)	(2)	(3)
Standardised LAM		0.00	0.01
		(-0.02, 0.03)	(-0.04, 0.05)
Condition (Friends-Alone)			0.08
			(-0.08, 0.24)
Condition (Strangers-Alone)			0.10
			(-0.07, 0.27)
Condition (Strangers-Friends)			0.02
			(-0.15, 0.19)
Standardised LAM: Condition (Friends-Alone)			-0.04
			(-0.10, 0.02)
Standardised LAM: Condition (Strangers-Alone)			0.04
			(-0.02, 0.10)
Standardised LAM: Condition (Strangers-Friends)			0.08***
			(0.02, 0.14)
Constant	0.09**	0.09**	0.03
	(0.02, 0.16)	(0.02, 0.16)	(-0.08, 0.15)
Observations	2,367	2,367	2,367
Log Likelihood	-2,157	-2,157	-2,153
Akaike Inf. Crit.	4,322	4,323	4,323
Bayesian Inf. Crit.	4,345	4,352	4,375
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 18

Fixed effects and 95% confidence intervals for models predicting mean corrugator supercilii activity. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Standardised mean corrugator activity		
	(1)	(2)	(3)
Standardised LAM		-0.15***	-0.11***
		(-0.18, -0.11)	(-0.16, -0.06)

Condition (Friends-Alone)			0.03
			(-0.15, 0.21)
Condition (Strangers-Alone)			-0.01
			(-0.20, 0.17)
Condition (Strangers-Friends)			-0.04
			(-0.23, 0.14)
Standardised LAM: Condition (Friends-Alone)			-0.03
			(-0.09, 0.04)
Standardised LAM: Condition (Strangers-Alone)			-0.10***
			(-0.17, -0.04)
Standardised LAM: Condition (Strangers-Friends)			-0.08**
			(-0.15, -0.01)
Constant	0.08	0.08*	0.07
	(-0.03, 0.18)	(-0.01, 0.16)	(-0.07, 0.20)
Observations	2,384	2,384	2,384
Log Likelihood	-2,447	-2,421	-2,416
Akaike Inf. Crit.	4,902	4,852	4,850
Bayesian Inf. Crit.	4,925	4,880	4,902
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 19

Fixed effects and 95% confidence intervals for models predicting mean levator labii superioris activity. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Standardised mean levator activity		
	(1)	(2)	(3)
Standardised LAM		-0.09***	-0.04
		(-0.12, -0.05)	(-0.09, 0.01)
Condition (Friends-Alone)			0.08

			(-0.13, 0.28)
Condition (Strangers-Alone)			0.25**
			(0.04, 0.46)
Condition (Strangers-Friends)			0.18
			(-0.04, 0.39)
Standardised LAM: Condition (Friends-Alone)			-0.07**
			(-0.13, -0.01)
Standardised LAM: Condition (Strangers-Alone)			-0.09**
			(-0.15, -0.02)
Standardised LAM: Condition (Strangers-Friends)			-0.02
			(-0.09, 0.05)
Constant	0.10*	0.10**	-0.01
	(-0.01, 0.20)	(0.01, 0.19)	(-0.15, 0.14)
Observations	2,391	2,391	2,391
Log Likelihood	-2,524	-2,516	-2,510
Akaike Inf. Crit.	5,057	5,041	5,037
Bayesian Inf. Crit.	5,080	5,070	5,089
Note:	*p<0.1; **p<0.05; ***p<0.01		

12 Appendix D: Supplementary Materials for Chapter 5

12.1 Preliminary analyses

12.1.1 Fixation and maximum contraction muscle activity by Study

Fixation muscle activity in the alone conditions of both studies did not differ for zygomaticus major or corrugator supercilii, but levator labii fixation activity was higher in study 1 compared to study 2 (M_1 = 0.31, 95% CI [-1.77, 2.19], M_2 = -0.39, 95% CI [-0.74, 0.96]; $t(58.81) = 3.23$, $p = .002$. Maximum voluntary contraction peak activity in the alone conditions of both studies did not differ for zygomaticus major or levator labii superioris, but corrugator supercilii maximum contractions were higher in study 1 compared to study 2 (M_1 = 0.39, 95% CI [-1.57, 2.35], M_2 = -0.15, 95% CI [-2.19, 1.89]; $t(58.53) = 2.06$, $p = .04$. Given that fixation and maximum contraction muscle activity in the Alone conditions of both studies were comparable, the data from both studies were combined and analysed as one dataset.

12.1.2 Fixation and maximum contraction muscle activity by Condition

Fixation muscle activity did not differ between conditions (all $p>.05$). Corrugator supercilii and levator labii superioris maximum contraction muscle activity did not differ between conditions but zygomaticus major muscle activity did ($F(3, 149) = 4.61$, $p = 0.004$, $\eta^2 = 0.09$). Post hoc comparisons using a Tukey HSD test indicated that zygomaticus major maximum contractions were smaller in the Friends condition compared to the Alone condition (M_{Diff} = -0.68, 95% CI [-1.23, -0.12], $p = .01$) and compared to the Observed condition (M_{Diff} = 0.67, 95% CI [0.04, 1.29], $p = 0.03$).

12.2 Rise time to peak

12.2.1 Study 1 (Alone and Observed)

Table 20

Fixed effects and 95% confidence intervals for models predicting zygomaticus major rise time to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	ZM rise time to peak		
	(1)	(2)	(3)
Peak ZM activity		0.096***	0.096***
		(0.047, 0.144)	(0.047, 0.145)
Condition (Observed-Alone)			0.008
			(-0.107, 0.122)
Constant	-0.0002	-0.0003	-0.004
	(-0.056, 0.056)	(-0.057, 0.057)	(-0.085, 0.077)
Observations	1,860	1,860	1,860
Log Likelihood	-2,635.031	-2,627.628	-2,627.620
Akaike Inf. Crit.	5,278.062	5,265.257	5,267.240
Bayesian Inf. Crit.	5,300.175	5,292.899	5,300.410
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 21

Fixed effects and 95% confidence intervals for models predicting corrugator supercilii rise time to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	CS rise time to peak		
	(1)	(2)	(3)
Peak CS activity		0.106***	0.103***
		(0.059, 0.153)	(0.056, 0.150)
Condition (Observed-Alone)			0.117*
			(-0.003, 0.237)
Constant	-0.001	-0.001	-0.060
	(-0.062, 0.060)	(-0.063, 0.061)	(-0.146, 0.025)
Observations	1,860	1,860	1,860
Log Likelihood	-2,630.651	-2,621.057	-2,619.275
Akaike Inf. Crit.	5,269.301	5,252.113	5,250.549
Bayesian Inf. Crit.	5,291.415	5,279.755	5,283.719
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 22

Fixed effects and 95% confidence intervals for models predicting levator labii superioris rise time to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	LL rise time to peak		
	(1)	(2)	(3)
Peak LL activity		0.083^{***}	0.083^{***}
		(0.031, 0.134)	(0.032, 0.135)
Condition (Observed-Alone)			0.028
			(-0.107, 0.164)
Constant	-0.0002	-0.0004	-0.015
	(-0.070, 0.069)	(-0.072, 0.071)	(-0.113, 0.084)
Observations	1,860	1,860	1,860
Log Likelihood	-2,624.824	-2,619.963	-2,619.879
Akaike Inf. Crit.	5,257.647	5,249.927	5,251.757
Bayesian Inf. Crit.	5,279.761	5,277.568	5,284.927
Note:	*p<0.1; **p<0.05; ***p<0.01		

12.2.2 Study 2 (Alone, Friends and Strangers)

Table 23

Fixed effects and 95% confidence intervals for models predicting zygomaticus major rise time to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	ZM rise time to peak		
	(1)	(2)	(3)
Peak ZM activity		0.144^{***}	0.146^{***}
		(0.099, 0.188)	(0.102, 0.191)
Condition (Friends-Alone)			-0.092
			(-0.229, 0.044)
Condition (Strangers-Alone)			-0.041
			(-0.186, 0.104)
Constant	-0.001	-0.001	0.043
	(-0.060, 0.058)	(-0.059, 0.057)	(-0.053, 0.140)
Observations	2,306	2,306	2,306
Log Likelihood	-3,256.595	-3,236.735	-3,235.860
Akaike Inf. Crit.	6,521.190	6,483.469	6,485.721

Bayesian Inf. Crit.	6,544.163	6,512.185	6,525.923
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 24

Fixed effects and 95% confidence intervals for models predicting corrugator supercilii rise time to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	CS rise time to peak		
	(1)	(2)	(3)
Peak CM activity		0.085***	0.087***
		(0.038, 0.132)	(0.040, 0.134)
Condition (Friends-Alone)			0.061
			(-0.105, 0.227)
Condition (Strangers-Alone)			-0.078
			(-0.254, 0.098)
Constant	-0.0001	-0.0002	0.0004
	(-0.074, 0.074)	(-0.073, 0.072)	(-0.118, 0.119)
Observations	2,306	2,306	2,306
Log Likelihood	-3,229.101	-3,223.104	-3,221.908
Akaike Inf. Crit.	6,466.202	6,456.208	6,457.816
Bayesian Inf. Crit.	6,489.175	6,484.924	6,498.019
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 25

Fixed effects and 95% confidence intervals for models predicting levator labii superioris rise time to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	LL rise time to peak		
	(1)	(2)	(3)
Peak LL activity		0.152***	0.156***
		(0.106, 0.199)	(0.109, 0.203)
Condition (Friends-Alone)			0.015
			(-0.140, 0.170)
Condition (Strangers-Alone)			-0.113
			(-0.278, 0.052)
Constant	0.001	0.0002	0.027

	(-0.067, 0.069)	(-0.068, 0.069)	(-0.084, 0.139)
Observations	2,306	2,306	2,306
Log Likelihood	-3,246.940	-3,227.179	-3,225.851
Akaike Inf. Crit.	6,501.879	6,464.357	6,465.702
Bayesian Inf. Crit.	6,524.852	6,493.073	6,505.905
Note:	*p<0.1; **p<0.05; ***p<0.01		

12.3 Rise to peak

Table 26

Fixed effects and 95% confidence intervals for models predicting standardised log10 zygomaticus major speed of rise to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Zygomaticus speed of rise to peak		
	(1)	(2)	(3)
Standardised LAM		0.035**	0.055**
		(0.003, 0.067)	(0.012, 0.097)
Condition (Observed-Alone)			0.178
			(-0.099, 0.456)
Condition (Friends-Alone)			0.152
			(-0.114, 0.418)
Condition (Strangers-Alone)			0.128
			(-0.171, 0.427)
Condition (Friends-Observed)			-0.026
			(-0.340, 0.288)
Condition (Strangers-Observed)			-0.051
			(-0.393, 0.291)
Condition (Strangers-Friends)			-0.025
			(-0.358, 0.309)
Standardised LAM: Condition (Observed-Alone)			-0.057*

			(-0.122, 0.009)
Standardised LAM: Condition (Friends-Alone)			-0.012
			(-0.074, 0.050)
Standardised LAM: Condition (Strangers-Alone)			-0.041
			(-0.114, 0.031)
Standardised LAM: Condition (Friends-Observed)			0.045
			(-0.029, 0.119)
Standardised LAM: Condition (Strangers-Observed)			0.015
			(-0.067, 0.098)
Standardised LAM: Condition (Strangers-Friends)			-0.030
			(-0.109, 0.050)
Constant	0.002	0.002	-0.088
	(-0.106, 0.109)	(-0.106, 0.110)	(-0.249, 0.072)
Observations	4,053	4,053	4,053
Log Likelihood	-4,904.740	-4,902.526	-4,899.687
Akaike Inf. Crit.	9,817.480	9,815.052	9,821.375
Bayesian Inf. Crit.	9,842.709	9,846.588	9,890.754
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 27

Fixed effects and 95% confidence intervals for models predicting standardised log10 corrugator supercilii speed of rise to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Corrugator speed of rise to peak		
	(1)	(2)	(3)
Standardised LAM		-0.174***	-0.157***

		(-0.209, -0.139)	(-0.203, -0.110)
Condition (Observed-Alone)			0.034
			(-0.189, 0.257)
Condition (Friends-Alone)			-0.015
			(-0.229, 0.199)
Condition (Strangers-Alone)			0.302**
			(0.061, 0.542)
Condition (Friends-Observed)			-0.049
			(-0.302, 0.203)
Condition (Strangers-Observed)			0.267*
			(-0.008, 0.543)
Condition (Stranger-Friends)			0.317**
			(0.048, 0.585)
Standardised LAM: Condition (Observed-Alone)			-0.039
			(-0.110, 0.032)
Standardised LAM: Condition (Friends-Alone)			-0.036
			(-0.103, 0.032)
Standardised LAM: Condition (Strangers-Alone)			0.0002
			(-0.079, 0.080)
Standardised LAM: Condition (Friends-Observed)			0.004
			(-0.076, 0.084)
Standardised LAM: Condition (Strangers-Observed)			0.040
			(-0.051, 0.130)
Standardised LAM: Condition (Strangers-Friends)			0.036
			(-0.052, 0.124)
Constant	-0.001	-0.003	-0.054
	(-0.120, 0.118)	(-0.095, 0.089)	(-0.186, 0.078)
Observations	4,035	4,035	4,035

Log Likelihood	-5,196.821	-5,169.798	-5,165.481
Akaike Inf. Crit.	10,401.640	10,349.600	10,352.960
Bayesian Inf. Crit.	10,426.850	10,381.110	10,422.290
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 28

Fixed effects and 95% confidence intervals for models predicting standardised log10 levator labii superioris speed of rise to peak. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Levator speed of rise to peak		
	(1)	(2)	(3)
Standardised LAM		-0.103***	-0.124***
		(-0.130, -0.077)	(-0.163, -0.085)
Condition (Observed-Alone)			0.062
			(-0.199, 0.323)
Condition (Friends-Alone)			-0.099
			(-0.349, 0.152)
Condition (Strangers-Alone)			0.399***
			(0.118, 0.680)
Condition (Friends-Observed)			-0.161
			(-0.456, 0.135)
Condition (Strangers-Observed)			0.337**
			(0.015, 0.659)
Condition (Strangers-Friend)			0.498***
			(0.184, 0.811)
Standardised LAM: Condition (Observed-Alone)			0.015
			(-0.052, 0.082)
Standardised LAM: Condition (Friends-Alone)			0.042
			(-0.022, 0.105)
Standardised LAM: Condition (Strangers-Alone)			0.063*
			(-0.011, 0.138)

Standardised LAM: Condition (Friends-Observed)			0.027
			(-0.049, 0.102)
Standardised LAM: Condition (Strangers-Observed)			0.048
			(-0.037, 0.133)
Standardised LAM: Condition (Strangers-Friend)			0.022
			(-0.060, 0.104)
Constant	0.005	0.004	-0.048
	(-0.102, 0.112)	(-0.095, 0.104)	(-0.196, 0.100)
Observations	4,071	4,071	4,071
Log Likelihood	-5,019.571	-5,002.678	-4,995.884
Akaike Inf. Crit.	10,047.140	10,015.360	10,013.770
Bayesian Inf. Crit.	10,072.390	10,046.920	10,083.200
Note:	*p<0.1; **p<0.05; ***p<0.01		

12.4 Return to baseline

Table 29

Fixed effects and 95% confidence intervals for models predicting standardised log10 zygomaticus major speed of return to baseline. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Zygomaticus speed of return to baseline		
	(1)	(2)	(3)
Standardised LAM		0.006	0.017
		(-0.025, 0.038)	(-0.026, 0.060)
Condition (Observed-Alone)			0.157
			(-0.109, 0.422)
Condition (Friends-Alone)			0.237*
			(-0.018, 0.492)
Condition (Strangers-Alone)			0.228
			(-0.059, 0.515)
Condition (Friends-Observed)			0.080

			(-0.221, 0.381)
Condition (Strangers-Observed)			0.071
			(-0.257, 0.399)
Condition (Strangers-Friends)			-0.009
			(-0.329, 0.310)
Standardised LAM: Condition (Observed-Alone)			-0.090**
			(-0.160, -0.021)
Standardised LAM: Condition (Friends-Alone)			0.011
			(-0.054, 0.076)
Standardised LAM: Condition (Strangers-Alone)			0.024
			(-0.052, 0.100)
Standardised LAM: Condition (Friends-Observed)			0.102**
			(0.023, 0.180)
Standardised LAM: Condition (Strangers-Observed)			0.114**
			(0.027, 0.202)
Standardised LAM: Condition (Strangers-Friends)			0.013
			(-0.071, 0.097)
Constant	0.010	0.010	-0.109
	(-0.093, 0.113)	(-0.093, 0.113)	(-0.262, 0.043)
Observations	3,959	3,959	3,959
Log Likelihood	-4,891.562	-4,891.494	-4,884.654
Akaike Inf. Crit.	9,791.124	9,792.988	9,791.308
Bayesian Inf. Crit.	9,816.259	9,824.407	9,860.429
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 30

Fixed effects and 95% confidence intervals for models predicting standardised log10 corrugator supercilii speed of return to baseline. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Corrugator speed of return to baseline		
	(1)	(2)	(3)
Standardised LAM		-0.157***	-0.177***
		(-0.189, -0.124)	(-0.222, -0.133)
Condition (Observed-Alone)			0.072
			(-0.164, 0.308)
Condition (Friends-Alone)			0.103
			(-0.123, 0.329)
Condition (Strangers-Alone)			0.242*
			(-0.013, 0.497)
Condition (Friends-Observed)			0.031
			(-0.236, 0.298)
Condition (Strangers-Observed)			0.170
			(-0.122, 0.461)
Condition (Strangers-Friends)			0.139
			(-0.145, 0.423)
Standardised LAM: Condition (Observed-Alone)			-0.027
			(-0.099, 0.044)
Standardised LAM: Condition (Friends-Alone)			0.052
			(-0.016, 0.120)
Standardised LAM: Condition (Strangers-Alone)			0.094**
			(0.016, 0.173)
Standardised LAM: Condition (Friends-Observed)			0.080*
			(-0.001, 0.160)
Standardised LAM: Condition (Strangers-Observed)			0.122***

			(0.032, 0.212)
Standardised LAM: Condition (Strangers-Friends)			0.042
			(-0.045, 0.129)
Constant	0.003	0.002	-0.071
	(-0.108, 0.114)	(-0.089, 0.094)	(-0.207, 0.065)
Observations	4,008	4,008	4,008
Log Likelihood	-5,145.314	-5,120.934	-5,114.600
Akaike Inf. Crit.	10,298.630	10,251.870	10,251.200
Bayesian Inf. Crit.	10,323.810	10,283.350	10,320.460
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 31

Fixed effects and 95% confidence intervals for models predicting standardised log10 levator labii superioris speed of return to baseline. Constant refers to the combined effect of participant and food image.

	Dependent variable:		
	Levator speed of return to baseline		
	(1)	(2)	(3)
Standardised LAM		-0.074***	-0.076***
		(-0.102, -0.045)	(-0.117, -0.035)
Condition (Observed-Alone)			0.007
			(-0.253, 0.267)
Condition (Friends-Alone)			0.009
			(-0.241, 0.259)
Condition (Strangers-Alone)			0.228
			(-0.053, 0.508)
Condition (Friends-Observed)			0.002
			(-0.292, 0.297)
Condition (Strangers-Observed)			0.221
			(-0.100, 0.542)
Condition (Strangers-Friends)			0.219
			(-0.094, 0.531)

Standardised LAM: Condition (Observed-Alone)			-0.050
			(-0.120, 0.021)
Standardised LAM: Condition (Friends-Alone)			0.055
			(-0.011, 0.122)
Standardised LAM: Condition (Strangers-Alone)			-0.007
			(-0.085, 0.070)
Standardised LAM: Condition (Friends-Observed)			0.105***
			(0.026, 0.185)
Standardised LAM: Condition (Strangers-Observed)			0.043
			(-0.046, 0.132)
Standardised LAM: Condition (Strangers-Friends)			-0.063
			(-0.148, 0.023)
Constant	0.007	0.007	-0.033
	(-0.095, 0.109)	(-0.091, 0.104)	(-0.181, 0.114)
Observations	3,989	3,989	3,989
Log Likelihood	-5,000.546	-4,992.244	-4,987.368
Akaike Inf. Crit.	10,009.090	9,994.488	9,996.736
Bayesian Inf. Crit.	10,034.260	10,025.940	10,065.940
Note:	*p<0.1; **p<0.05; ***p<0.01		

13 Appendix E: Supplementary Materials for Chapter 6

13.1 Mean muscle activity and subjective liking

Table 32

Fixed effects and 95% confidence intervals for mean muscle activity models predicting subjective liking. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	LAM	
	(1)	(2)
Mean ZM activity		1.39***
		(0.75, 2.02)
Mean CS activity		-1.61***
		(-2.24, -0.97)
Mean LL activity		-1.078***
		(-1.74, -0.42)
Constant	54.22***	54.23***
	(45.65, 62.80)	(45.87, 62.59)
Observations	4,166	4,166
Log Likelihood	-18,127.22	-18,099.38
Akaike Inf. Crit.	36,262.43	36,212.77
Bayesian Inf. Crit.	36,287.77	36,257.11
Note:	*p<0.1; **p<0.05; ***p<0.01	

13.2 Peak muscle activity and subjective liking

Table 33

Fixed effects and 95% confidence intervals for peak muscle activity models predicting subjective liking. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
Peak ZM activity		2.10***
		(1.42, 2.78)
Peak CS activity		-2.29***
		(-3.01, -1.58)

Peak LL activity		-1.43***
		(-2.15, -0.71)
Constant	54.22***	54.23***
	(45.65, 62.80)	(45.97, 62.49)
Observations	4,166	4,166
Log Likelihood	-18,127.220	-18,080.890
Akaike Inf. Crit.	36,262.430	36,175.780
Bayesian Inf. Crit.	36,287.770	36,220.130
Note:	*p<0.1; **p<0.05; ***p<0.01	

13.3 Rise to peak and subjective liking

Table 34

Fixed effects and 95% confidence intervals for rise to peak models predicting subjective liking. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM rise to peak		1.14***
		(0.44, 1.84)
CS rise to peak		-1.49***
		(-2.16, -0.82)
LL rise to peak		-0.97***
		(-1.67, -0.27)
Constant	54.10***	54.12***
	(45.55, 62.64)	(45.73, 62.50)
Observations	3,852	3,852
Log Likelihood	-16,778.690	-16,760.300
Akaike Inf. Crit.	33,565.380	33,534.590
Bayesian Inf. Crit.	33,590.400	33,578.390
Note:	*p<0.1; **p<0.05; ***p<0.01	

13.4 Return to baseline and subjective liking

Table 35

Fixed effects and 95% confidence intervals for return to baseline models predicting subjective liking. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM return to baseline		0.64*
		(-0.06, 1.34)
CS return to baseline		-1.20***
		(-1.88, -0.52)
LL return to baseline		-0.35
		(-1.05, 0.35)
Constant	54.27***	54.27***
	(45.78, 62.76)	(45.85, 62.68)
Observations	3,711	3,711
Log Likelihood	-16,161.490	-16,153.240
Akaike Inf. Crit.	32,330.980	32,320.490
Bayesian Inf. Crit.	32,355.850	32,364.020
Note:	*p<0.1; **p<0.05; ***p<0.01	

13.5 LMM tables for each second of trial

Table 36

Fixed effects and 95% confidence intervals for models predicting subjective liking for the whole duration of the trial. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM (0-5000ms)		1.39***
		(0.75, 2.02)
CS (0-5000ms)		-1.61***
		(-2.24, -0.97)
LL (0-5000ms)		-1.08***
		(-1.74, -0.42)
Constant	54.22***	54.23***
	(45.65, 62.80)	(45.87, 62.59)

Observations	4,166	4,166
Log Likelihood	-18,127.22	-18,099.38
Akaike Inf. Crit.	36,262.43	36,212.77
Bayesian Inf. Crit.	36,287.77	36,257.11
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 37

Fixed effects and 95% confidence intervals for models predicting subjective liking for the first second of the trial. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM (0-1000ms)		0.05
		(-0.52, 0.63)
CS (0-1000ms)		-1.40***
		(-2.01, -0.78)
LL (0-1000ms)		-0.27
		(-0.86, 0.33)
Constant	54.22***	54.23***
	(45.65, 62.80)	(45.75, 62.71)
Observations	4,166	4,166
Log Likelihood	-18,127.22	-18,116.25
Akaike Inf. Crit.	36,262.43	36,246.50
Bayesian Inf. Crit.	36,287.77	36,290.84
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 38

Fixed effects and 95% confidence intervals for models predicting subjective liking for the second second of the trial. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM (1000-2000ms)		1.28***
		(0.65, 1.91)
CS (1000-2000ms)		-1.68***
		(-2.30, -1.07)

LL (1000-2000ms)		-1.35^{***}
		(-2.01, -0.70)
Constant	54.22^{***}	54.27^{***}
	(45.65, 62.80)	(45.97, 62.57)
Observations	4,166	4,088
Log Likelihood	-18,127.22	-17,737.87
Akaike Inf. Crit.	36,262.43	35,489.74
Bayesian Inf. Crit.	36,287.77	35,533.95
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 39

Fixed effects and 95% confidence intervals for models predicting subjective liking for the third second of the trial. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM (2000-3000ms)		1.36^{***}
		(0.71, 2.02)
CS (2000-3000ms)		-1.47^{***}
		(-2.09, -0.85)
LL (2000-3000ms)		-1.08^{***}
		(-1.74, -0.43)
Constant	54.22^{***}	54.25^{***}
	(45.65, 62.80)	(45.91, 62.59)
Observations	4,166	4,076
Log Likelihood	-18,127.22	-17,706.86
Akaike Inf. Crit.	36,262.43	35,427.72
Bayesian Inf. Crit.	36,287.77	35,471.91
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 40

Fixed effects and 95% confidence intervals for models predicting subjective liking for the fourth second of the trial. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM (3000-4000ms)		1.38^{***}
		(0.73, 2.03)
CS (3000-4000ms)		-1.22^{***}
		(-1.85, -0.59)
LL (4000-5000ms)		-0.91^{***}
		(-1.58, -0.23)
Constant	54.22^{***}	54.25^{***}
	(45.65, 62.80)	(45.89, 62.62)
Observations	4,166	4,076
Log Likelihood	-18,127.22	-17,720.49
Akaike Inf. Crit.	36,262.43	35,454.97
Bayesian Inf. Crit.	36,287.77	35,499.16
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$	

Table 41

Fixed effects and 95% confidence intervals for models predicting subjective liking for the fifth second of the trial. Constant refers to the combined effect of participant and food image.

	Dependent variable:	
	Subjective liking	
	(1)	(2)
ZM (4000-5000ms)		1.34^{***}
		(0.70, 1.99)
CS (4000-5000ms)		-0.99^{***}
		(-1.63, -0.36)
LL (4000-5000ms)		-0.74^{**}
		(-1.40, -0.08)
Constant	54.22^{***}	54.25^{***}
	(45.65, 62.80)	(45.83, 62.68)
Observations	4,166	4,082

Log Likelihood	-18,127.22	-17,747.49
Akaike Inf. Crit.	36,262.43	35,508.98
Bayesian Inf. Crit.	36,287.77	35,553.18
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$	

14 Appendix F: Facial electromyography and subjective liking data from 70 New Zealand participants in response to food images and chocolate samples

Abstract

This article describes a dataset of facial electromyography and subjective liking data from 70 New Zealand participants used in the study "An unfamiliar presence reduces facial disgust responses to food stimuli" by Nath, Cannon and Philipp [1]. Participants' facial muscle activity from zygomaticus major, corrugator supercilii, and levator labii superioris was recorded as they viewed and rated food images, and tasted samples of chocolate. Half of the participants were seated alone, and the other half were seated in the presence of the researcher. The data allows for investigations into the effect of social context on hedonic ratings and facial responses to food, and an exploration into the individual factors contributing to differences in facial reactivity. The data includes raw EMG files generated by Acqknowledge 4.2, raw subjective liking files generated by PsychoPy, a table of participant information, the food images stimuli, the PsychoPy code used for stimuli presentation, and the R scripts used to filter, aggregate and analyse the data.

Specifications Table

Subject	Experimental and Cognitive Psychology
Specific subject area	Psychophysiology, consumer psychology
Type of data	Table of participant demographics (.csv file) Food Images (.jpeg files) PsychoPy stimuli presentation program code (.py file) EMG raw data (.acq files) EMG raw data (.csv files)

	Subjective liking raw data (.csv files) R data processing and analysis code (.R files)
How data were acquired	Facial electromyography data was acquired via a BIOPAC MP150 physiological recording device (BIOPAC Systems Inc., Goleta, CA). Subjective liking data was acquired via a labelled affective magnitude scale [2] presented using a custom PsychoPy program [3].
Data format	Raw data
Parameters for data collection	Data was collected from participants living in Auckland, NZ, aged 18 and above, and who were fluent in English.
Description of data collection	Participants' facial muscle activity from zygomaticus major, corrugator supercilii and levator labii superioris were recorded while viewing thirty food images and consuming two small pieces of chocolate either alone, or in the presence of the researcher.
Data source location	Institution: Massey University City/Town/Region: Albany, Auckland Country: New Zealand Latitude and longitude (and GPS coordinates) for collected samples/data:] -36.73572, 174.6922
Data accessibility	Repository name: Zenodo Data identification number: 1208749 Direct URL to data: https://zenodo.org/record/3462883

Related research article	Elizabeth C. Nath, Peter R. Cannon, Michael C. Philipp An unfamiliar social presence reduces facial disgust responses to food stimuli Food Research International https://doi.org/10.1016/j.foodres.2019.108662

Value of the Data

- The data consists of recordings from three facial muscles involved in emotional facial expressions and other functional facial movement. It allows for a richer understanding of how food stimuli, social context and individual differences influence facial expression.

- Emotion researchers can use this data to better understand individual differences in facial expression generation. Consumer researchers can use this data to better understand hedonic and implicit emotion responses to food stimuli.

- These data allows for investigations into the effect of social context on hedonic ratings and facial responses to food, and the demographic information allows for explorations into the individual factors contributing to differences in facial reactivity.

- Muscle activity data during the consumption of chocolate samples allows for investigations into the effect of sensory properties of chocolate such as hardness, bitterness, fat content and melting point on functional and emotional facial muscle activity.

Data

The dataset provided with this article contains raw facial electromyography data from the zygomaticus major, corrugator supercilii and levator labii superioris muscles of 70 participants as they viewed 30 food images and sampled two pieces of chocolate. Electromyography data is provided in both .acq and .csv file formats. Participant information and their assigned experimental condition is included in a separate .csv file. The order of presentation of the food images was randomized for each participant and this order is contained in each participants' .csv file. The food image stimuli are included as .jpeg files. The experiment instructions and stimuli were presented via PsychoPy using a custom program; this code is included as a .py file. The R scripts used to filter, aggregate, and analyse the data are included as .R files. Given that this data was collected in New Zealand, where the mains electricity frequency is 50 Hz, it will require band stop filters every 50Hz to remove mains frequency interference and harmonics prior to analysis.

In the marker channel of each .acq file, each unique marker corresponds to a trial event period as in Table 1 below.

Table 1. Marker number allocations for .acq files

Marker number	Trial event
10	Food image baseline
20	Food image
30	Dark chocolate consumption
40	Milk chocolate consumption
100	Corrugator supercilii maximum voluntary contractions
150	Levator labii superioris maximum voluntary contractions

Experimental Design, Materials, and Methods

1 Participants

Seventy participants (52 women, 18 men) aged between 18 and 74 (M = 28.8, SD = 10.0) and primarily of Asian and NZ European descent were recruited via advertisements placed around the university campus and on local community Facebook groups. Advertisements were in English and asked for participants to be 18 years and older. No other exclusion criteria were stipulated. All participants gave written consent and were compensated for their time with a NZ$15 department store or supermarket gift card.

2 Design

Participants were randomly assigned to one of two experimental conditions – alone or observed. Participants in the alone condition were directed to sit in front of a computer screen in a sound-attenuated testing booth (Figure 1A) while participants in the observed condition were directed to sit in front of a computer screen beside the experimenter in the main lab (Figure 1B).

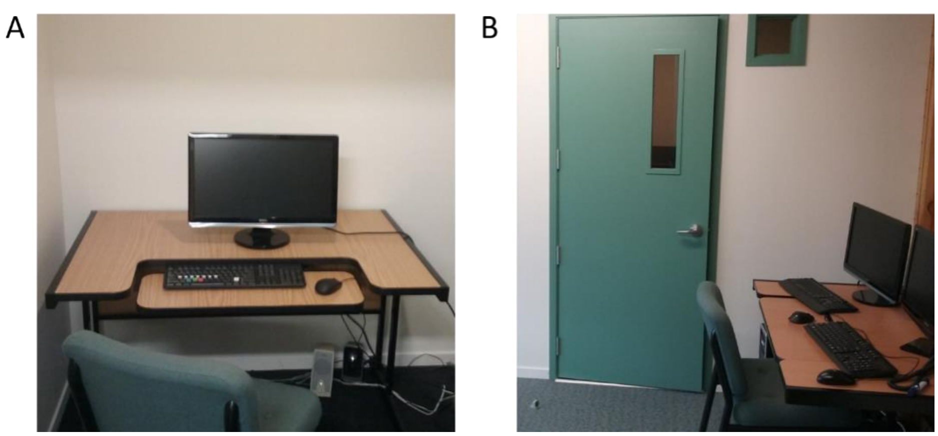

Figure 1. (A) Experimental setup for participants in the Alone condition. (B) Experimental setup for participants in the Observed condition. The green door leads into the testing booth depicted in photograph A.

3 Stimuli

Thirty food images were selected such that their perceived acceptability would likely be distributed along the entire valence scale (ranging from greatest imaginable like to greatest imaginable dislike). In their study on food images and acceptability conducted in Auckland, New Zealand, Li [4] found that the local sample rated images of familiar foods such as cake, roast chicken and chocolate highest in acceptability and rated images of unfamiliar foods from foreign cultures such as Balut (Philippines) and Svið (Iceland) lowest in acceptability. The images were presented with PsychoPy [3] on a 60.5 cm Philips monitor with 1920 × 1080 resolution and a 60 Hz frame rate. The chocolate stimuli consisted of one 3g piece of Whittaker's 62% Dark Cocoa Block, followed by one 3g piece of Whittaker's 33% Creamy Milk Block. The order of presentation of the chocolate stimuli was always in this sequence (i.e. not randomised for each participant). The timing of trial events was synchronised with the psychophysiological recording software via parallel port. All images used in the present study are licensed for reuse.

4 Measures

4.1 Subjective liking ratings

Subjective liking was measured using the labelled affective magnitude scale (LAM), developed by Schutz and Cardello [2] to measure food liking. The LAM is a vertical, 100-point, line scale with 11 semantic anchors ranging from "greatest imaginable dislike" at 0, to "greatest imaginable like" at 100.

4.2 Facial electromyography

Muscle activity from zygomaticus major (contraction lifts corner of mouth during smiling), corrugator supercilii (contraction knits brow during frowning) and levator labii superioris (contraction wrinkles nose during expressions of disgust) [5] on the left side of the face was recorded using a BIOPAC MP150 physiological recording device, three BIOPAC amplifiers, and six 4 mm Ag/AgCl reusable surface electrodes (BIOPAC Systems Inc., Goleta, CA). The approximate location of each pair of electrodes is indicated in Figure 2. An 8 mm ground electrode was attached to the forehead near the hairline.

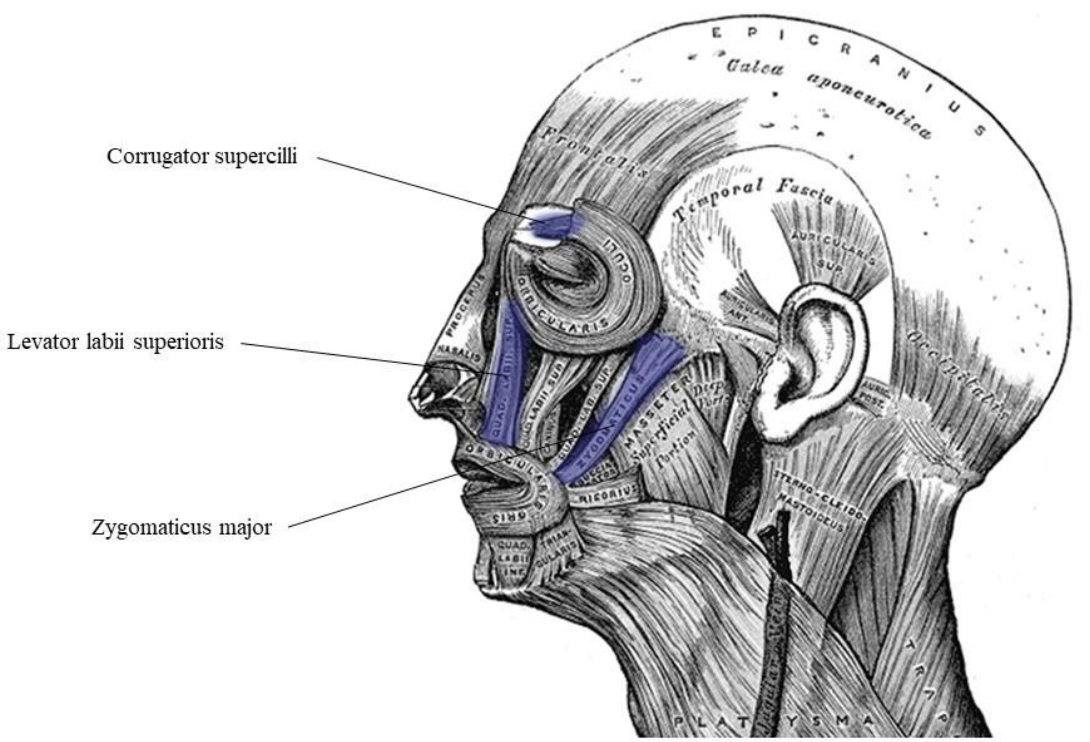

Figure 2. Position of corrugator supercilli, levatorlabi superioris and zygomaticus major muscles. Adapted from Anatomy of the Human Body by H. Gray, 1918, Philadelphia, PA: Lea &Febiger

5 Procedure

Upon expressing interest in the study, potential participants were emailed a study information sheet describing the experimental procedure. The information sheet explained that the purpose of the study was to investigate facial behaviours in response to food images and as such, participants were blind to the social context manipulation. On arrival at the lab, each participant was asked to sign a consent form and given a NZD$15 gift card. To prepare the skin sites for electrode adhesion, participants were first asked to wash their face with a mild facial cleanser. Then, the skin sites were cleaned with an alcohol swab and abraded with an abrading pad. A small amount of electrode gel was applied to each skin site with a cotton bud and any excess gel was wiped off with a tissue. Once the electrodes were attached, participants in the alone condition were directed to sit in front of a computer screen in a sound-attenuated testing booth while participants in the observed condition were directed to sit in front of a computer screen beside the experimenter in the main lab. The participants' chair was positioned such that their faces were between 60 and 70 cm from the monitor. In the observed condition, the experimenter sat silently beside the participant facing the screen and maintained a neutral expression and body language. The seating arrangement was such that direct eye contact between the participant and experimenter was not possible. In both conditions, the experimenter ran a simulation of the experiment and demonstrated response requirements before starting the main experiment. In the main experiment, participants viewed thirty food images presented in a randomised order and rated their liking of each food image on the LAM scale. Each trial consisted of a fixation screen displayed for 5000 ms (a white "+" presented in the centre of the screen against a grey background), a food image displayed for 5000 ms (a 1024 × 768 pixel image presented in the centre of the screen against a grey background) and a rating screen (the LAM scale in white font against a grey background) displayed until the participant made a response (refer to Figure 3 for an illustration). Participants were required to indicate their liking with a single mouse click on the scale. Following the food images, participants were asked to sample a piece of dark chocolate and a piece of milk chocolate (approximately 3 g in weight) and rate their liking on the LAM scale. After participants rated the food images and chocolate samples, maximum facial muscle contractions were recorded with the aid of on-screen prompts to pose a frown, wrinkle the nose and smile. Finally, the experimenter removed the electrodes and debriefed participants, explaining the full objectives of the study.

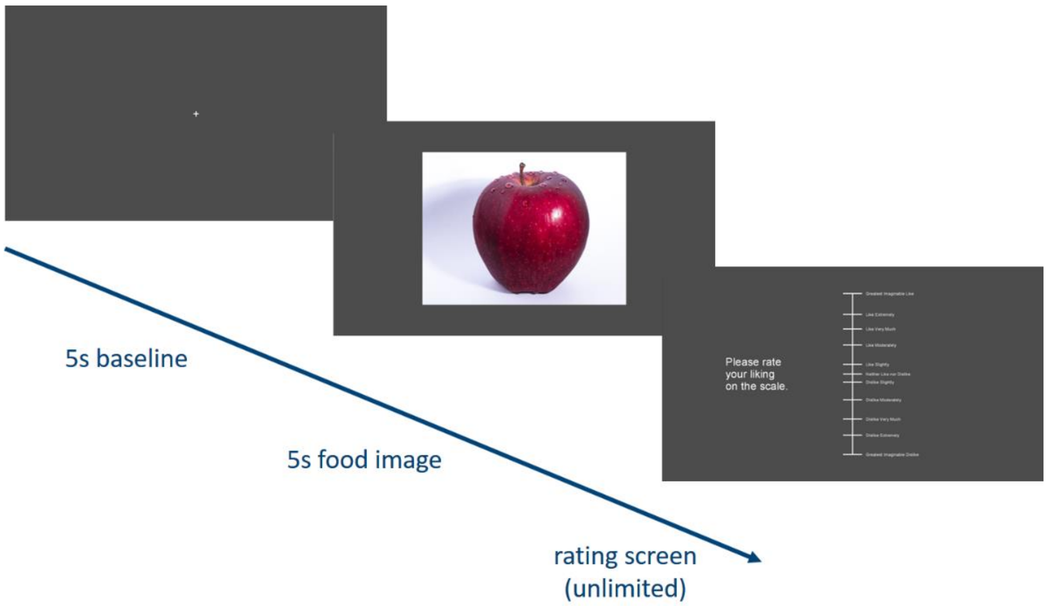

Figure 3. Sequence of trial events. Experimental stimuli was programmed and presented in PsychoPy[3].

6 Data processing

The EMG signals were relayed through shielded cable to Biopac amplifiers set to a gain of 5000 with a high pass filter at 1 Hz. The signal was digitally recorded at 2000 Hz using Acqknowledge 4.2 software. Raw data files were uploaded regularly during the data collection phase to a Zenodo online depository (https://zenodo.org/record/3462883) and are available under the Creative Commons Attribution Share-Alike 4.0 licence.

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We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Elizabeth Nath
Name/title of Primary Supervisor:	Dr. Peter Cannon
Name of Research Output and full reference:	
Nath, E. C., Cannon, P. R., & Philipp, M. C. (in press). The influence of timing, location and social setting on hedonic and emotional evaluations of past eating experiences. British Food Journal.	
In which Chapter is the Manuscript /Published work:	Chapter 2
Please indicate:	
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and	
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We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Elizabeth Nath
Name/title of Primary Supervisor:	Dr. Peter Cannon
Name of Research Output and full reference:	
Nath, E. C., Cannon, P. R., & Philipp, M. C. (2019). Co-acting strangers but not friends influence subjective liking and facial affective responses to food stimuli. Food Quality and Preference, 103865.	
In which Chapter is the Manuscript /Published work:	Chapter 4
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	100%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Conceptualisation, methodology, software, formal analysis, investigation, data curation, writing, visualisation	
For manuscripts intended for publication please indicate target journal:	
Candidate's Signature:	
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Name of candidate:	Elizabeth Nath
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Name of Research Output and full reference:	
Nath, E. C., Cannon, P. R., & Philipp, M. C. (2020). Facial electromyography and subjective liking data from 70 New Zealand participants in response to food images and chocolate samples. Data in Brief, 105124.	
In which Chapter is the Manuscript /Published work:	Appendix 14
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Date:	16/02/2020
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