Psychological Factors in Food Aversions, Nausea, and Vomiting During Pregnancy

Todd R. Schachtman1,*, Diana Klakotskaia1, Jennifer M. Walker2, Andrew J. Hill3

1Department of Psychological Sciences, University of Missouri, Columbia, Missouri, United States of America
2Department of Medicine, Division of Diabetes, Endocrinology and Metabolism, Vanderbilt University Medical Center, Nashville, Tennessee, United States of America
3Academic Unit of Psychiatry & Behavioral Sciences, School of Medicine, University of Leeds, Leeds, United Kingdom

*Corresponding author: schachtmant@missouri.edu

Abstract The etiology of nausea and vomiting during pregnancy (NVP) involves many variables that influence its onset, duration, and severity; and it is well known that its occurrence has health implications for the offspring. This review focuses on psychological and psychosocial factors as influences on NVP (“morning sickness”), including cultural, social, and associative variables. Certain foods are more likely to result in NVP than others, and this often stems from women’s experiential history with those food substances, including the potential to form associative-based aversions. Moreover, acknowledging the role of associative factors could influence the magnitude of NVP. Many demographic variables (e.g., geographical regions, age, socio-economic status) are related to NVP, but whether a population has more women with NVP may be due to certain foods being more common or rare in the diet of that population, as predicted by theories of associative processes. Consideration of the role of associative processes on NVP has implications for understanding its cause and magnitude. Also, mood and poorer psychological adjustment can exacerbate NVP. Issues related to management or treatment of the disorder are reviewed.

Keywords: nausea, vomiting, pregnancy, conditioning, morning sickness, NVP


1. Introduction

Preferences for certain flavored substances change over the course of a person’s life due largely to experience. These changes can occur because of developmental effects, learning experiences, health challenges, and other factors. It is well known that pregnancy can result in changes in food preferences, leading some substances to produce food avoidance or aversions, and the experience of nausea and/or vomiting. This review will focus on many known influences on nausea and vomiting during pregnancy (NVP), including cultural factors, associative processes, factors related to social interaction, and others. This review focuses on NVP rather than hyperemesis gravidarum in particular, but some findings involving hyperemesis gravidarum will be noted. It is important to consider the etiological factors involved in NVP and, in fact, many of the findings mentioned in this review concern possible causes of NVP. Like many, or all, medical conditions, there are physiological changes that occur when the disorder occurs; yet, psychological and social factors can influence the onset or progression of the disorder.

2. Characteristics of the Disorder

Regarding food avoidance, detailed retrospective research has noted that of 99 women, 61% had at least one taste aversion during pregnancy [1]. Patil noted a similar prevalence of aversions in a sample of pregnant women from rural Tanzania [2]. NVP is frequently experienced by women -- being responsible for approximately 8.5 million missed working days per year in the United Kingdom [3,4]. Research suggests that considerably more than half of pregnant women have nausea and vomiting during pregnancy [5,6,7]. Lacroix, Eason, and Melzack [8] found that 74% of women reported nausea lasting a mean of 34.6 days, with the median being 27 days. Women in this study filled out a daily booklet in which they recorded the intensity of nausea at four different times of the day; nausea was initiated at a mean of 8.2 weeks gestation in that study. Twenty-three percent of the women in the study had daily nausea for an average of 44.6 days. Chortatos, Haugen, Iversen, Vikranes, Magnus, and Veierod [9] found that nausea was experienced for longer durations during pregnancy in women that experienced both nausea and vomiting (a mean of 9.6 weeks), than those that did not experience vomiting (a mean of 7.4 weeks). Nausea was seen as early as the week of conception (gestational age of three weeks), although it more commonly began at five weeks of pregnancy. On average, vomiting occurred 9.8 times, and occurred on 5.6 days during pregnancy in this study. Interestingly, the prevalence of nausea and vomiting was greatest at 11 weeks (very end of first trimester) and the severity peaked at 11-13 weeks [6,7]. While nausea certainly does occur...
during the second trimester, it tends to decrease for many women during this period [10]. Less than two percent of women had nausea only in the mornings. Eighty percent of women experiencing nausea distributed across all of the days’ time periods. Thus, Flaxman and Sherman [11] point out that the term “morning sickness” is a misnomer.

Nausea and vomiting have implications for the health of the fetus or embryo. Indeed, some have argued that they should be seen as protective, and predict better pregnancy outcomes [2,5,12,13,14,15]; therefore, the term “disorder” may be misleading. If a woman experiences vomiting during pregnancy, there is a smaller chance the baby will be premature (i.e., less likely gestation will be 37 weeks or less), and there is a smaller chance of miscarriage [5]. Women with hyperemesis gravidarum, by contrast, are at increased risk of preterm birth [16]. Nausea and vomiting predict a reduction in the chance of spontaneous abortion (due to the oregano-spiced seasoning). The research also found aversions for meat and Italian food such as candy (especially chocolate), fruit, fish, and ice cream. There were aversions for meat and Italian food (due to the oregano-spiced seasoning). The research examining various vegetables is somewhat conflicted in that some vegetables elicit an aversion in some women, while producing a craving in other women.

The present review provides a narrative overview of the factors involved in morning sickness, and the results and conclusions that have been obtained. The review does not attempt a systematic or evaluative analysis of all the research findings, which should include epidemiological, anthropological, clinical, sociobiological, and experimental findings.

3. Theories of NVP

Why do women develop nausea, vomiting, and aversions to flavors during pregnancy? There are three broad theories that are often addressed in the literature [23]: 1) sensory changes; 2) cultural effects; and 3) the maternal/embryotic protection theory. Some of the data discussed in this review touch on these major theories, but the present review will not provide a detailed analysis of these theories, as many other papers have already provided such a discussion [23,24]. We will only describe these theories briefly here.

Regarding sensory changes during pregnancy, hormonal changes and other alterations in the internal milieu can result in sensory sensitivity changes that may influence the palatability of certain flavors [25]. Pregnancy can increase sensitivity to the taste or smell of substances. This theory has not received much empirical support. Researchers [26,27] have consistently found certain changes in sensory processing as a result of pregnancy (e.g., the smell and taste of coffee and tea are often rated as unpleasant, particularly during the first trimester). However, such changes do not explain why strong aversions occur for some foods and not others.

A second theory involves cultural factors. This view addresses the fact that avoided substances have symbolic, cultural meaning for individuals, and these substances are often those that produce nausea in pregnant women. Cultural factors are discussed later in this review. A third more accepted theory is a functionalist, evolution-based theory, which argues that NVP and food aversions have developed as an adaptive response to disease vulnerability to protect the mother and/or fetus. Pepper and Roberts [28] reported that NVP indirectly results in higher levels of placental growth by decreasing maternal energy intake which directs nutrients away from the mother and towards the placenta. Relatedly, Huxley [29] proposed that aversions reduce energy intake which, through lowered insulin levels, increases the availability of energy for growth to the developing fetus. However, Fessler [30] points out that this notion conflicts with the cravings for sweets and fruits that frequently occurs during this time [20]. However, vomiting during pregnancy has been found to be associated with lower birth weight in offspring [2].

Elevated levels of human chorionic gonadotropin, a hormone produced during pregnancy, produce nausea, and this nausea adaptively induces phytotoxicity avoidance [31]. Foods such as meats and vegetables, and drinks like coffee, tea, and alcohol, contain teratogenic, mutagenic, and abortifacient chemicals [20]; thus aversion to such substances can be adaptive. However, these aversions are not necessarily entirely adaptive, given that they may reduce the intake of essential amino acids, which are important for placental development [32]. Pepper and Roberts [28] found that nausea and vomiting are correlated with the amount of macronutrients in the food (e.g., meat). Fessler [30] has taken this idea further in saying that these aversions keep the mother and fetus healthy during a period of immunosuppression early in pregnancy (immunosuppression to prevent rejection of the growing semi-allograft tissue of the offspring). In support of this view, NVP occurrence is mostly during the first trimester when the woman’s immune system functioning is decreased, and when risk of infection/illness is large [30]. Specifically, Fessler, Eng, and Navarrete [33] reported that women in their first trimester have greater disgust sensitivity than those in the second or third trimester, and this is well correlated with a decrease in
immunocompetence. Worthington-Roberts, Little, Lambert, and Wu [34] studied women in the Seattle area and found that almost all of the women in their study reported craving some food or beverage during the last trimester of pregnancy and that half of the women reported an aversion. Lower income, lower education, and being nonmarried were correlated with more cravings postpartum; and women with these qualities were more likely to be nonlactators. That is, women that did not breastfeed had more postpartum cravings.

Bayley and Dye [35] point out the complexity of the arguments and some difficulties with the adaptive or maternal/embryo protection hypothesis. Most importantly, these theories fail to acknowledge the role of conditioning factors as a cause of these symptoms.

4. Cultural Differences and Demographic Factors

A number of cultural, ethnic, and socioeconomic variables have been found to be important in the frequency of NVP. Patil and Young [36] noted the role of culture in stating that, “Because an intense…rejection of…a food, drink, or smell is determined by a wide variety of influences, a biocultural approach is necessary to fully consider their etiology and meanings.” Worthington-Roberts et al. [34] observed that, “the significance of physiological versus cultural/psychological factors in the etiology of [food cravings and aversions] remains to be defined.”

Steinmetz, Abrams, and Young [6], studying women in Zanzibar, did not find a difference in NVP occurrence for low-income countries and resource-rich countries. With respect to age, Patil [2] found that older women tended to have more nausea or NVP, while Chortatos et al. [9], using a Norwegian sample, found NVP to be higher in younger women; and Petitti [18] found nausea to be greater in younger women. An early study by Fairweather [17] focused on the number of prior births mothers had and found that, for Caucasian women, vomiting was more common with firstbirths and in younger women (those under 35). However, studies by Patil [2] and Petitti [18] found that NVP or nausea was higher in those with more prior births. Vomiting [17] and NVP [9] were found to be more common in those with larger body weights. Considering other demographic variables, Chortatos et al. [9] found that women with NVP tended to be shorter in height and to be married. Vomiting was also more common in nonsmokers [17]. One important factor in understanding these conflicting findings is the different populations of women evaluated in the studies. Clearly these studies show that factors such as maternal body weight and experience with prior pregnancies are critical variables, and nausea and vomiting have somewhat different demographic characteristics.

Black women were found to experience more vomiting than Caucasian women [17]. However, many of these effects have not been replicated [18,37]. Klebanoff et al. [5] found that racial differences in vomiting varied a lot based on location (comparisons were made among New Orleans, Buffalo, Boston, Memphis, Richmond, and Minneapolis). That is, racial differences occurred in some parts of the country but not others. They concluded, however, that: geographic, socioeconomic, or local factors, that is, factors other than race (for instance, they mention variations in interviewing techniques at particular locations) could explain racial differences emerging across locations. Petitti [18] found that nausea was unrelated to race and education. However, note that Klebanoff et al. [5] studied the occurrence of vomiting, while Petetti [18] studied nausea.

One way that cultural factors can influence aversions to flavors is that certain foods are consumed more or less often in a certain culture, and this frequency or infrequency can influence the occurrence of aversions. As discussed later, there are conditioning processes that predict whether food aversions and preferences will occur based on how common the food substance is in the culture/society (preexposure prior to pregnancy). Acquiring aversions to flavored substances is typically greater if the substance is relatively novel. Are the foods that produce the most aversion in a particular culture nearly always a rare item with respect to how often it is consumed by that culture? Bayley, Dye, and Hill [20] point out work by Stewart, Wheeler, and Schofield [38] showing that food aversions tend to occur more often for less popular foods for the particular group [11]. One quarter of all food aversions were for substances consumed once per day. This may seem like a fairly small portion of the total aversions; however, it is somewhat remarkable that flavor aversions occur to any foods in which extensive earlier exposure occurred during the absence of illness, given that food preexposure is expected to reduce the chance of conditioning [20]. Conversely, it is possible that women report having fewer aversions than they actually experience given all the foods consumed around the time of nausea. It seems they should have more aversions than they do. Bayley et al. [1] reported that all but one woman in their study had aversions to foods they had consumed previously. Nevertheless, Bayley, Dye, and Hill [20] found that nearly half of the food aversions were for items infrequently consumed. Since aversions do occur to familiar substances shows that rarity of the food is clearly not a necessary condition for producing an aversion.

Coronios-Vargas, Toma, Tuveson, and Schutz [39] examined four ethnic groups in the U.S. (Caucasian, Hispanic, African-American, and Cambodian) with respect to similarities and differences in both cravings and aversions during pregnancy. Similarities between the groups included cravings for fruit and aversions to meat. One difference was a significantly higher aversion to dairy products in Cambodians; all groups except Cambodians craved milk. Caucasians and African-Americans showed a higher aversion to fermented fish, while Hispanics and Cambodians showed a higher aversion to peanut butter. NVP was also associated with low cereal consumption (a carbohydrate), but, as mentioned, NVP is also associated with high sugar (a carbohydrate) consumption.

An early study examining craving in black women from Tuskegee, Alabama from 1949-1951 obtained very different results [40]. Pregnant women exhibited a craving for clay, fish, chicken, cornstarch, and apples but rarely craved candy and milk. The Tuskegee study caused Hook [22] to analyze white and black woman separately in his study, but no significant differences were found. Hook concluded, like Klebanoff et al. [5], that, “it seems that
cultural and local geographic factors (rather than race or ethnicity) play a significant role with regard to cravings.” Such factors include how frequently certain foods tend to be ingested in the women’s community prior to pregnancy as mentioned (that less frequently consumed foods will be less likely to be involved in an aversion during pregnancy). For instance, it was reported that black women generally eat more fruit, and therefore have a craving for fruit during pregnancy rather than an aversion to it. However, we have also discussed how commonly consumed foods, such as meat in some cultures, seem more likely to result in NVP.

Another factor that pertains to both conditioning processes and cultural influences on food responses is the idea of “contagion” [41]. A food item can become associated with disgust if the food is seen as contaminated or unhealthy (even erroneously such that the individuals are certain that no pathogens are involved in any way). For example, if a food item makes contact with a sterilized cockroach, then the idea of consuming such an item is considered disgusting. That is, disgust has a strong “ideation component” (whereas nausea does not). Disgust has an important culturally-defined component, which explains the variation among peoples for expressing disgust to certain items. There is a relationship between societal taboos and disgust and the relationship appears to be an interesting one: Fessler [33] said that taboos do not produce disgust but, rather, disgust produces the taboo. Navarette, Fessler, and Eng [42] and Fessler et al. [33] examined disgust, a psychological experience, and nausea, a physiological experience. In the latter study, the authors found a strong correlation between reported level of nausea and overall disgust sensitivity throughout the course of pregnancy. While controlling for nausea as a covariate (controlling for the different levels of nausea that women might feel at different time points of their pregnancy), the authors found elevated disgust sensitivity during the first trimester (relative to the other trimesters). Other cultural effects exist. Roheim [43] found that “Aranda [an area in Australia] women describe numerous dreams linking pregnancy, bitter tastes, meat eating and nausea.” Clearly NVP can have far-reaching effects for the well-being of many cultural groups. The analysis of NVP among cultural groups reveals a variety of findings, some of which require additional research for needed resolution.

5. Mood, Psychological Well-Being, and Sickness

Changes in mood and psychological well-being can accompany the occurrence of food aversions. In a longitudinal study, Ochsenbein-Kolble et al. [26] examined olfactory function and mood in 38 pregnant women and 46 non-pregnant controls. Participants were evaluated at 12, 21, and 36 weeks of pregnancy, and 7 weeks after delivery. Results from the mood questionnaire showed that pregnant women rated themselves as feeling less well in terms of mood than controls, but only during the first and third trimesters. The authors attributed these effects to nausea/vomiting influencing mood during the first trimester and increased body weight influencing mood in the third trimester. Monitoring food aversions and cravings over a 7-day period in 100 women who ranged from week 5 to week 16 of pregnancy, Bayley et al. [20] found that anxiety scores and rated nausea were both significantly higher prior to the onset of aversions. As the food aversion experience continued, there was a further increase in nausea, a decrease in hedonic tone (happiness), and a further increase in anxiety. Unsurprisingly, both at the start and at the end of food aversion experiences, ratings of nausea were significantly and negatively correlated with happiness and were positively correlated with anxiety. Feelings of sickness may produce anxiety and, in turn, anxiety may promote feeling sick. However, mood appears to be a far less potent context for food aversions than for food cravings, with the latter seen as affect-prompted and affect-regulating experiences that can influence food consumption [44]. Still, the responses stemming from conditioned taste aversions can influence affect and mood.

Psychological well-being (GHQ-assessed) has been found to correlate significantly with nausea and vomiting [4]. Indeed, pregnant women experiencing nausea and vomiting in the study by Swallow et al. [4] had a higher incidence of psychiatric disorders than non-pregnant women in general. Given the correlations, the authors entertained the hypothesis that psychological distress can result in more incidences of nausea and vomiting rather than NVP leading to psychiatric pathology. However, as pointed out by Swallow et al. [4], some studies have not found a relationship between psychiatric disorders and NVP [45]. Furthermore, McCarthy et al. [16] found that women in several western countries (Ireland, United Kingdom, Australia, New Zealand) that experienced hyperemesis gravidarum had significantly larger scores on assessments related to poor psychological health and adjustment, including anxiety, stress, and depression. Uguz, Gezgin, Kayhan, Cicek, and Kantarcı [46] found that major depression, generalized anxiety disorder, avoidant personality disorder, and obsessive-compulsive disorder were higher in women with hyperemesis gravidarum, but most of these conditions were experienced prior to the onset of the pregnancy. However, Fejzo and MacGibbon [47] point out that the majority of women in the Uguz et al. [46] study did not have a preexisting anxiety or mood disorder prior to the pregnancy, and they claimed, therefore, that genetic contributions to hyperemesis gravidarum should be emphasized rather than prior psychological history. It should also be kept in mind that some women may feel anxious or guilty about their food or consumption choices while pregnant and this can be a source of distress.

6. Effects of Social Interactions

Social interactions and relationships/behavior dynamics may have an influence on NVP and food aversions. In one study [20], it was found that the majority of aversions and cravings (roughly 70%) were experienced in the company of other people, whether at home or at work. Seventy-six percent of aversions occur in the company of others. Of course, there may be many reasons why this might occur. If some women have a large amount of social interaction at home and/or work during the day, then their food aversions/cravings are likely to occur in this context by
chance alone. Additionally, Bayley et al. [20] mention that most aversions are experienced at home — only 22% of aversions occur away from home or work. Iatrakis, Sakellaropoulos, Kourkoubas, and Kabounia [48] stated that stress related to poor communication between husbands and wives and other partners is associated with the severity of NVP [9]. Some researchers have discussed issues surrounding the fact that morning sickness often happens in the presence of others. Researchers have claimed that illness has instrumental utility for women. For example, Fessler [30] and Schwab and Axelson [49] stated that in some cultures women explicitly iterate their cravings during pregnancy with the aim at exercising power over their husbands, inspiring them to obtain a food for them that they normally would not be able to have. They suggest that craving for items/substances and these instrumental actions may stem from gender inequality [30]. The role of food substances in the culture could, therefore, have an influence on relationship dynamics and vice versa. However, a paper by Munch [50] on the topic of hyperemesis gravidarum refutes this idea of instrumentality and power, while stressing that the disorder is clearly a physiological one, albeit with some psychological causal factors. According to Munch [50], focusing on the “instrumentality” of the disorder may belittle other important aspects of its etiology.

Another way in which social interactions can influence NVP is by aversions that are acquired through socially-mediated conditioning [51,52,53]. Fessler and Navarrette [54] found that ingestive taboos are acquired through socially-mediated conditioning, in which a few members of the culture (perhaps admired individuals) exhibit reluctance to consume a substance and this reluctance becomes prevalent in the group. It is well established that many factors can enhance the degree of socially mediated conditioning in humans. Such factors include the similarity of the “mimic” to the “model,” as well as the “status” of the model in the peer groups [55,56]. Finally, it has been long established that individuals reinforce (and punish) each other for their choices [57]. Women will consume foods and experience consequences for their choices when in the company of others. Family members, co-workers, and friends may condone, empower, chastise, and, generally, influence the consummatory choices of the individual. The pregnant woman will also be subject to the influence of others when they voice their aversion experiences and other aspects of NVP.

7. Conditioning Processes and the Occurrence of NVP

Sensory changes, changes in hormone levels, and cultural factors may cause nausea or food rejection, but they do not sufficiently account for the potential for learned aversions and conditioned responses of nausea. Conditioning or associative processes offer a fourth and currently less frequently acknowledged influence on NVP. Associative processes can influence the occurrence of NVP through their effects on food exposures prior to pregnancy, social reinforcement factors, context-flavor associations, odor-flavor associative interactions, the influence of the presence of more than one flavor at the time of feeling ill, as well as other effects. These influences are discussed below. It should also be mentioned that nausea and its role in conditioning is subject to genetic determination. Mattes [58] noted that animal models suggest that the propensity to develop aversions in response to nausea is heritable; therefore, genetic properties can influence the degree of nausea, which can influence the extent of conditioning of aversions to the food substance.

Conditioning processes are the most evidenced and theory-supported mechanisms for food aversions. Nausea and vomiting during pregnancy can result in learned taste aversions. If a woman feels ill and consumes a certain food during this experience, then a learned aversion to the food can occur through classical conditioning [59,60]. This process of acquiring aversions is similar to the way in which cancer patients acquire taste aversions when receiving chemotherapy or radiotherapy [61]. Learned taste aversion is a critical and adaptive learning process possessed by humans and other animals. Conditioned taste aversion learning prevents the repeated self-administration of toxic food; therefore it is very compatible with the maternal/embryo protection view. Nonetheless, the relationship between nausea and conditioning is a complex one (e.g., does nausea produce aversions or is it a conditioned response based on a conditioning experience with the aversive food?); and full appreciation of this relationship requires consideration of the variety of processes that underlie conditioning. Beyond the direct relevance to food selection, dietary habits, and eating disorders, certain clinical populations are prone to the adverse consequences of the development of conditioned taste aversions induced by medical treatments [62,63].

The conclusions stemming from studies reporting on simple associations between nausea, vomiting and aversions across pregnancy are somewhat limited. Rodin’s work [64] as well as that of Crystal, Bowen, and Bernstein [65] found that the severity of nausea and vomiting was correlated with the number of aversions that women had acquired. Likewise, Chortatos et al. [9] found that moderate levels of vomiting during pregnancy were associated with increased food aversions. In contrast, neither Dickens and Trethowan [10] nor Patil [2] found any relationship between the relative frequency of aversions, nausea and vomiting. This difference in outcome may be resolved by taking a more proximal view, that is, by investigating whether nausea and vomiting occur when an aversion is acquired. This work is discussed next.

Since experimental work with pregnant women is not very feasible, one must rely on correlational results and “naturalistic experiments” that occur while women encounter events distributed over time during their everyday lives. Rescorla [66] defined the conditions in which a researcher can claim that associative learning (classical conditioning) has occurred. An experimental condition receives pairings of a CS (food substance) with the US (internal malaise). An appropriate control condition is one in which the CS and US are not paired together (poor contiguity) or in which there is a lack of the contingent relationship that is given in the experimental condition. In the latter case, the two events are presented randomly in time, such that they bear no temporal relationship with one another. These two conditions define when associative learning can be said to occur. Indeed, the
co-occurrence of a flavored substance and internal malaise which leads to the avoidance of the flavor by pregnant women -- when compared to a condition in which these events are not paired (poor contiguity) -- can serve as a working definition of NVP acquired through associative processes.

Bayley et al. [1] examined cases in which the food substance and illness occurred in close temporal proximity (“experimental condition”) and those for which the events were separated in time (“control”). Of course, it is well known that conditioned taste aversions can be formed even with longer periods of time between the events (conditioning in some subjects with other procedures decreases rapidly if only a few seconds occur between the events); nonetheless, Bayley et al [20] found that the variation in contiguity for the pregnant women influenced whether aversions occurred, a finding consistent with an associative perspective [66].

Similarly, Rodin and Radke-Sharpe [19] failed to find that nausea and vomiting during one trimester predicted an aversion in a following trimester, but did establish that the nausea and vomiting and the acquisition of aversions tended to occur in the same trimester. Vomiting-aversion relationships (that is, the two events tending to occur together in time) are even more common than nausea-aversion relationships. Bayley, Dye, and Hill [20] examined the time course of aversions and nausea, and found that the occurrence of nausea significantly predicted a food aversion. However, aversions did not predict nausea [9]. This occurs if nausea reliably results in an aversion but an aversion does not always predict nausea. When nausea and aversion do occur together, an aversion is very often preceded by nausea.

The above evidence shows the importance of events (food substances and nausea/vomiting) occurring close together in time. The formation of associations between these events can arise from such contiguity; and various experiences can enhance or slow the development of rejection of certain food substances that occur due to the acquisition of aversions. These experiences include: 1) changes in palatability of certain foods due to sensory changes (one of the theories as to why morning sickness occurs); 2) consumption of a food substance while feeling nauseous during pregnancy and forming an aversion because of the experience; and 3) a taste aversion learned prior to becoming pregnant that influences the willingness to consume the substance during pregnancy. The potential for conditioning exists during most or all of these experiences and can contribute to NVP.

Modern conditioning theory claims that associative learning results in the formation of expectancies, such that a response (operant conditioning) or a conditioned stimulus (classical conditioning) results in the expectation of an important stimulus consequence (reward, punishment, or an unconditioned stimulus) [66]. Some background information about conditioning will be valuable. During classical conditioning, a neutral event (the conditioned stimulus or CS) is paired with an event that is typically of biological significance (the unconditioned stimulus or US). In Pavlov’s classic demonstration, a tone served as the CS and food as the US. After such pairings, the CS becomes capable of producing a conditioned response (CR, salivation in Pavlov’s early example) to the CS. The CS (tone) had no tendency to produce the CR for the subjects prior to the pairings. In operant or instrumental conditioning, a response is followed by an outcome (e.g., a punishment or positive reinforcer). Typically, this response occurs in the presence of a stimulus (e.g., a light), sometimes called a “discriminative stimulus,” when it is followed by the outcome. The pairing of these events causes the response to be more likely or less likely in the future (especially when the light is present).

There are several possible processes acknowledged to underlie conditioning experiences [66]. First, an association between the response and the outcome is believed to be formed during operant conditioning (R-O associations). Second, an association between the stimulus (the light in the example just provided that is present during response-outcome pairings) and the response can be formed (a S-R association) during operant conditioning. The former association (R-O) is often discussed as an expectancy of the outcome that occurs when the response is produced. The latter (S-R) association is viewed much like a habit in that the stimulus (the discriminative stimulus, the light in our example) automatically elicits the response, without being mediated by an expectancy [67], [68]. Third, a CS-US association is believed to develop during classical conditioning. This association involves an expectancy of the US when the CS is presented. Fourth, a S-R association between the CS and the conditioned response can occur as a result of classical conditioning, and the occurrence of this conditioned response based on this association is also “habit like” -- the conditioned response (CR) occurs automatically when the stimulus is presented, and is not believed to be based on an expectancy or an activated representation of the outcome at the time of the CR. Hence, with a conditioned aversion, a S-R association would mean that seeing a food substance would elicit rejection without an activation of the feeling of illness. Finally, a fifth process is evaluative conditioning, which can occur during classical conditioning. This process results in a conditioned response to the CS, but is not based on an expectancy of the US when the CS is presented. Furthermore, a S-R association is not involved in evaluative conditioning. Instead, the CS changes in value because it has been
paired with the US [69]. The conditioned response occurs because of the cognitive assessment of the CS’s new value.

The conditioning phenomena that may be relevant to NVP are described below. Each section makes predictions about when foods will or will not result in nausea or aversions. When conditioned taste aversion (CTA) was first discovered, the field of learning and conditioning expended much effort to determine what associative processes are involved (for instance, were they the same associative processes that governed other types of conditioning?). They did this by examining whether CTA possessed the same influences and phenomena that are observed with other conditioning procedures (e.g., fear conditioning). This is the same approach we have adopted in this review. In other words, does the development of NVP yield similar phenomena to those seen in other types of conditioning? And, in other cases, we emphasize variables or phenomena that should be examined in future work to explore this. To the extent that the role of associative processes in NVP is not yet confirmed, then this will assist the field by identifying findings that support this role. And, as we point out, some parallel effects can be seen in pregnant women that correspond to conditioning effects. Moreover, it should be mentioned that associative processes are not incompatible with the other views. Regardless of the existence of sensory changes that can occur with pregnancy, cultural factors that may influence NVP, or the idea that food aversions are adaptive -- associative processes may exert an influence on the acquisition of food aversions during pregnancy. Associative learning is clearly adaptive and, further, it is dependent on sensory sensitivity (the salience of the CS). It should be mentioned that if associative learning processes do not influence NVP, then experience must produce aversions some other way. This may occur do to changes in sensory sensitivity or some other process that causes food substances to become newly avoided. The food substance would induce an aversion or avoidance independently of an association with internal malaise.

7.1. Preparedness and Categories of Food Items Involved in NVP

Preparedness is well known as a factor that greatly influences conditioning [70]. Some associations are more readily learned than others -- a very straightforward claim and yet one that goes against an earlier Skinnerian notion of “equipotentiality.” Fessler and Navarrete [54] described this phenomenon clearly when they said that foods that are readily converted into aversions could become privileged as “the target of acquired conditioned aversions.” Therefore, these substances may be particularly prone to producing an aversion during pregnancy if they occur around the time of nausea. Flaxman and Sherman [11] show that the food items that are likely to produce aversions (meat, fish, poultry, beverages such as coffee, and vegetables) are common in society. Interestingly, Chortatos et al. [9] found that pregnant women with nausea and vomiting had the greatest meat consumption and the greatest vegetable consumption, in comparison to women experiencing only nausea or experiencing neither nausea or vomiting. They also found that women without either nausea or vomiting consumed the most protein, fat, and saturated fats during the pregnancy (potentially from food sources besides meat or vegetables). Patil [2] found aversions for meat and vegetables to be common. Hence, some frequently consumed foods (e.g., meat) may be more “prepared” substances for developing a CTA, at least for pregnant women.

Pepper and Roberts [28] observed a link between NVP and intake of all macronutrients, and claimed that NVP is better predicted by animal products (as opposed to vegetable products). This view would thereby claim that animal products are particularly prepared to result in learned aversions. Indeed, Bayley et al. [20] report that high protein foods are “over-represented” in aversions. Fessler [30] stated that, “in both humans and nonhumans proteinaceous foods are the principle target of conditioned aversions.”

Another issue involves women’s food reactivity and preferences prior to pregnancy. Crystal et al. [65] found that women who were more reactive to food before becoming pregnant (more likely to develop aversions and cravings prior to pregnancy) were more likely to experience aversions and cravings during pregnancy. Fessler [30] noted, “Pregnancy thus appears to entail an amplification of reactions that are present outside of pregnancy.” That is, whatever substance one mildly does not care for prior to the pregnancy will be greatly avoided during pregnancy, and a food that is preferred before the pregnancy can become very strongly preferred. Therefore, pre-pregnancy attitudes toward a food item may influence the degree of preparedness.

In contrast, Bayley et al. [20] found that women who: 1) had a least one experience with the food during pregnancy; and 2) actually liked that food, would then develop an aversion to it. If a preference for the food somehow increases the chance of an aversion, then this effect is counterintuitive; it also deviates from the research showing that stimuli that are prepared to become associated with aversive outcomes often have a pre-experimental negative affective attitude towards the stimulus (e.g., photographs of snakes are readily conditioned) [71]. Stimuli that are prepared to become associated with appetitive outcomes often have a pre-experimental positive affective attitude (e.g. photographs of sunsets) [71]. The reason for the contrasting views of pre-pregnancy attitudes is not clear; but differences may pertain to the type of food preferred, how common the food is in the diet, or, again, the population of women studied.

Prepared associations have been described as S-R associations in which the stimulus elicits the CR automatically in a habit-like way, in contrast to nonprepared or contraprepared associations (associations that are particularly slow to be learned about) in which the CS and US are not evolutionarily predisposed to result in such associations [70], [71]. Contraprepared associations have been described as more expectancy-based, and involve cognitive processes that are distinct from the S-R habit-like responses of prepared associations [70], [71]. Research is needed to explore the type of association acquired during pregnancy and the extent that expectancy mediates the nausea/aversion response.

7.2. Latent Inhibition

Stewart, Wheeler, and Schofield [38] claimed that food aversions tend to occur for less popular foods. As
mentioned earlier, this implies that aversions are readily acquired to foods that have been encountered relatively less often in the person’s experience prior to conditioning. Foods that have been given a lot of (safe) exposure previously (because they are commonly encountered among people for that culture) will be poor at producing an aversion if they are later paired with an experience of sickness. With this phenomenon, stimulus pre-exposure slows subsequent classical conditioning when the stimulus is paired later with an outcome; it is an effect called latent inhibition, and it is one of the most well-studied and easily demonstrated effects in classical conditioning [72]. A pre-exposed stimulus is expected to result in poor classical conditioning when paired with the unconditioned stimulus and such a stimulus is called a “latent inhibitor.” Bayley et al. [1] reported that all but one woman in their study had aversions to foods they had consumed previously (prior to the pairing with illness). Nevertheless, Bayley et al. [20] found that nearly half of the food aversions were for items infrequently consumed. We have also mentioned that Flaxman and Sherman [11] show that some of the food items that are likely to produce aversions (meat, fish, poultry, beverages such as coffee, and vegetables as stated previously) are common in many of the societies that were evaluated in their study. Bayley et al. [20] purported that one quarter of all food aversions were for foods consumed at least once per day. All of these findings, collectively, may suggest that frequency of prior exposure of a food item is not a simple issue; many factors (latent inhibition versus preparedness, as described above) may be functioning. The fact that aversions occur to familiar substances shows that rarity of the food is not a necessary condition for producing an aversion.

Another concern is that it is possible that women report having fewer aversions than they actually experience. That is, given all the foods consumed around the time of nausea, it seems they should have more aversions than they do; but the familiarity of dietary items may thereby reduce the number of foods that would otherwise become aversive (again, suggesting a latent inhibition effect) [20]. As will be discussed later, if both a familiar food and an unfamiliar food are present at the time of nausea, the unfamiliar food is more likely to result in an aversion than the familiar food [73,74].

One other question should be kept in mind with respect to the commonality of food items in the society and its effect on NPV. What if pregnant women tend not to consume novel foods (i.e. have strong neophobia to new flavors)? If they do not, then it is not surprising that so many of their aversions are to common, frequently-encountered food substances. Commonly consumed foods would be more likely to be present at the time of sickness than a rare food, and would, therefore, possess a tendency towards more aversions just based on sheer probability.

7.3. Overshadowing
If two stimuli, such as two flavors, are present at the time of an outcome (illness or nausea), the two stimuli will compete for learning [75]. This phenomenon is called “overshadowing” and it shows that less conditioning occurs to a stimulus paired with the outcome in the presence of another stimulus. Poor learning occurs for a group that receives two flavors paired with illness and is compared to a group in which a single stimulus (one flavor) is paired with illness. Such a compounding of tastes during presentation is common. We often consume meals consisting of many foods, and even a simple snack may contain many flavors. Competition among stimuli to become associated with the outcome is arguably the most important finding in conditioning theory during the past forty years. By being present when the outcome occurs, one stimulus is said to attenuate learning of the other stimulus, that is, “overshadow” learning about the other stimulus. Food stimulus properties such as a distinctive bitter taste may be especially salient and may possess an associative advantage. This issue is related to preparedness, as described above. This may give the food substance an especially good ability to be learned about at the expense of another food substance.

7.4. Attenuation of Overshadowing By A Latent Inhibitor
As mentioned, some foods are consumed by women more than other food prior to pregnancy. The degree of prior exposure can influence conditioning via latent inhibition. In addition to being slow to be learned about, another way that a previously experienced (pre-exposed) stimulus can influence taste aversions during pregnancy is by its inability to overshadow another stimulus. That is, if a stimulus is paired with the outcome (nausea) in the presence of another stimulus that has been pre-exposed previously (i.e., a latent inhibitor), this latent inhibitor will be poor at preventing learning to the other stimulus [74,75]. Put differently, if a familiar food as well as an unfamiliar food are present at the time of nausea, the unfamiliar food is more likely to result in an aversion than the familiar food [73,74]. The non-pre-exposed stimulus will be well learned about. Again, the phenomenon of latent inhibition likely keeps many flavors from being conditioned, and this allows other foods to be learned about.

7.5. Taste-Potentiated Odor Aversion
A great deal of conditioning research has shown important interactions between odor and taste. It is well known that odor has a huge influence on how a food tastes. The research literature has also shown that sometimes an odor will compete with the taste for conditioning (produce overshadowing as described above). However, at other times the taste can enhance the degree of aversion to the odor [76]. This phenomenon is called taste-potentiated odor aversion. Bayley et al. [20] discuss the way in which odor alone is not always an effective CS when paired with the US itself [77]; yet odor can become associated with the taste (CS-CS associations) to facilitate the taste aversion (CS-US association). Bayley et al. [20] go on to state that the “presence of an odor with a taste may make a food a very potent target for a taste aversion.” This may explain why coffee and tea and cooked meat substances (all of which can have strong odors) have a strong tendency to result in taste aversions, despite their frequent presence in some societies. Patil et al. [24] note that many women report changes in olfaction during the first trimester of pregnancy in which formerly innocuous odors are then perceived as unpleasant. These changes in the
salience and/or aversiveness of odors may influence the interactions of odors and taste. They also point to research suggesting that aversions to food during pregnancy may be due to genetic variation in sensitivity to food with bitter tastes, and, therefore, women may vary in their susceptibility to odor-taste interactions.

7.6. Medicine Effect

A conditioning phenomenon that has received scant attention in the empirical literature and deserves more study, both with respect to its replicability and examination of its underlying processes, is the “medicine effect [78,79].” First, in fear conditioning, if an aversive outcome (US) occurs and then is followed by a conditioned stimulus, a treatment known as “backwards conditioning,” the CS can become a signal for safety [80,81]. With respect to learned flavor aversions, if a flavor (CS) is presented after illness (US), such that the flavor is presumed to occur at the time that the subject may be recovering from the illness, and the flavor can become preferred (relative to a control condition for which the flavor has not been accompanied by recovery from illness) [78]. Bayley et al. [1] found that for the 65% of women who experience both nausea and food cravings during pregnancy, the first food craving occurred at least 2 weeks after the first occurrence of nausea. Bayley et al. [1] wondered if this indicates that, for some women, cravings develop for foods associated with relief from nausea. This possibility introduces the notion that cravings for pregnant women may, on occasion, result from a “medicine effect” that stems from the timing of illness and exposure to the flavor. The CS may signal recovery from illness.

7.7. Conditioned Inhibition

Perhaps a distant cousin of the medicine effect, conditioned inhibition occurs when a conditioned stimulus (CS) predicts that the outcome (US) will explicitly not occur. There are many conditioning procedures that will train a CS to become a conditioned inhibitor. Wilson [82] surmised that aversions for foods can stem from the foods’ inability to provide important macronutrients such as protein [83]. Thus, a flavor can result in an aversion if it predicts an absence of critical, needed nutrients. This is a possible instance of conditioned inhibition of flavor learning. The flavor predicts the absence of an outcome (nutrients). Paradoxically, conditioned inhibition has not been found in conditioned taste aversion learning using the more “classic” conditioned inhibition training procedures first described by Pavlov [84,85]. Nonetheless, women may learn aversions to flavors for these reasons. In other words, aversions may stem from flavors signaling the absence of healthy outcomes.

7.8. Extinction

Extinction refers to the decrease in CR when a CS, that has been previously paired with an unconditioned stimulus, is presented without the unconditioned stimulus. The research on aversions acquired during pregnancy shows that, while conditioned taste aversions normally endure for years after they are acquired, aversions acquired during pregnancy frequently do not continue into the postpartum period [34,86]. Interestingly, aversions in chemotherapy patients also do not last as long as they last in non-clinical populations [87,88]. However, a rapid loss of aversions for pregnant women is not always found. Bayley et al. [20] mention that “55% of woman reporting food aversions said their first food aversion was still present [after pregnancy].” Assuming some aversions are lost rapidly, why are they lost so rapidly?

Cravings may also be short-lived. Worthington-Roberts et al. [34] reported that, after delivery, cravings for some substances tended to continue, but the aversions ended abruptly. Interestingly, postpartum cravings differed for lactators versus non-lactators. Having lower income, lower education, and being unmarried were correlated with more postpartum cravings; additionally, such women were more likely to be non-lactators. There are other associative phenomena that may prove valuable for those studying the acquisition of aversions in pregnant women, including work by Berridge [89,90] on wanting/liking and issues regarding implicit learning of food aversions [91,92].

8. Future Directions

It is clear that NVP involves many different variables. This review has focused on psychological and psychosocial factors, including associative processes as well as cultural and social variables. Certain foods are also more likely to produce NVP and the degree that a food produces NVP may depend on the culture of the women. Many demographic variables seem to be related to NVP. Some of these variables may be due, in part, to certain foods being more common or rare in the diet for particular groups. One clear offering from some of the research reviewed here is that exposure to food substances (or lack of familiarity) prior to the pregnancy can have many effects, including influences on the potential for the women to form an aversion to the food. The relationship between how common the food substance is in the culture and the degree of NVP may be a complicated mix of several influential factors. An examination of the time course of experiences of nausea, aversions, and vomiting reveals that the occurrence of nausea predicts aversions, but the occurrence of aversions do not always predict nausea.

Conditioning potentially exerts an influence on the development of NVP. Many issues related to associative learning have implications for the acquisition and treatment of NVP, including: 1) the fact that some foods could be more prepared to become associated with an aversion experience (“preparedness”) [71,92]; 2) the recent acknowledgement of evaluative conditioning, such that food-illness pairings can either cause the food item to signal an aversive event (traditional classical conditioning effect) or that the food changes in its perceived value after conditioning (the latter being evaluative conditioning) [69]; 3) the role of contagion, such that food substances can become associated with contamination and will be perceived as erroneously harmful [41]; 4) the influences of social learning: modeling as well as the appetitive or aversive consequences provided by others to a pregnant woman in response to her behaviors (consummatory choices, communicating to others about their NVP experiences); 5) the effects of other food substances on
conditioning of the “target” food substance, including competition and even potentiation of learning; 6) whether aversive, rejection, or vomiting responses are elicited by the food in a stimulus-response “habit-like” manner (the food substance elicits rejection without the activation of the feeling of illness) or, alternatively, rejection may be mediated by a cognitive representation of the feeling of sickness. Researchers are also alerted to the potential role of many other conditioning effects, including those of contextual cues [93].

Mood and poor psychological adjustment and distress can exacerbate NVP. There are also many phenomena related to NVP that remain in need of more research. All six of the associative processes just described can be subjected to empirical testing to examine their role in NVP. For instance, many published works in the associative learning field have examined whether a conditioned response is mediated by activation of the memory representation of the aversive (or appetitive) outcome that gave rise to conditioning in the first place [94]. If the conditioned response (rejection of the food) occurs because the sight of the food activates a representation of the state of feeling sick, then a drug that alleviates illness (e.g., ondansetron) should reduce the rejection response. If the rejection response occurs automatically at the sight of the food, then rejection will occur even if the individual does not feel sick (via an activated representation of sickness) when they see the food.

Other findings require more investigation. For example, Crystal et al. [65] found a significant increase in salt preference in offspring of women that experienced a lot of vomiting during pregnancy. This effect was not due to factors related to their familial dietary practices. But it might have been an effect of volumetric depletion or electrolyte imbalance during gestation. They report that there was a small decrease in amount of salt consumed in pregnant women that vomit a lot. One purpose of this review has been to point out issues and directions that remain to be explored in attempting to better understand the causes and treatment of NVP.

8.1. Management of NVP

There are data promoting the effectiveness of various manipulations that can aid in the unwanted side effects of NVP. That is, even if the overall value of NVP is adaptive for the mother and offspring, some aspects of the experience can be difficult for the mother and fetus. Exposure to the avoided food without illness occurring (extinction), certain consumption practices (drinking carbonated beverages), and medications can prove valuable in dealing with the unwanted effects of NVP. Swallow et al. [4] noted that, “it is possible that psychological therapies may be helpful in the treatment of nausea and vomiting during pregnancy.” Certainly many anti-emetic drugs such as ondansetron can be used with non-pregnant women for their symptoms of nausea and vomiting. For conditioned aversions, extinction could be a recommended course for decreasing a conditioned response to the flavor; however, urging a woman to be exposed to a (currently) unpalatable substance will not be a pleasurable experience. Moreover, it might be remembered from the discussion above that such aversions often dissipate “on their own” once the woman is no longer pregnant (in contrast to regular conditioned taste aversions that can last a lifetime).

Lacroix et al. [8] found that eating carbohydrates and carbonated drinks helped with nausea or vomiting (according to the reports of the participants in their study), and this confirms other findings in the published literature [95,96,97,98]. Harbord [99] used controlled trials and found a small benefit of using ginger to help nausea, as well as effects of using vitamin B6 (pyridoxine).

Finally, given that extinction exposures will likely reduce the conditioned aversion, conditioning principles and techniques can be used to improve the chance of eliminating aversions. There are many such techniques including counterconditioning, extensive extinction, contextual manipulations that reduce “renewal,” and treatments that prevent US-reinstatement-induced increases in the CR can all be effective to prevent the reoccurrence of the CR [100,101,102,103]. The issue of preparedness should be considered here. If women form aversions to foods that are “contraprepared” (and we might assume that foods that are highly preferred prior to pregnancy such as sweets might be otherwise less likely to become associated with illness), they are expected to extinguish quickly to such aversions. Prepared associations are expected to extinguish more slowly [71,92]. So, cultural factors (making certain foods biased or nonbiased towards entering into associations with aversive outcomes) and pre-pregnancy food preferences may influence the rate of avoidance reduction. Although conditioning likely plays a role in the development of NVP, Little and Hook [104] remind us that nausea and vomiting do not always support conditioning even when food substances are consumed at the time of nausea and/or vomiting. Conditioning trials will not always produce a conditioned aversion. Similarly, nausea and vomiting at the time of cigarette consumption do not always cause smokers to quit smoking [104]. We know that, in such a case, the power of addiction can offset the effects of conditioning, whereas the conditioning of many foods would not face a large obstacle as the power of drug addiction, and are not likely to involve powerful withdrawal symptoms (a strong desire to maintain consumption). Ironically, while carbohydrate snacks are frequently recommended to women to reduce NVP symptoms, Chortatos et al. [9] note that carbohydrates themselves can also lead to nausea. Nonetheless, Chortatos et al. [9] did find that women with NVP tended to consume more carbohydrates (especially soda). In sum, although some causal and correlative factors regarding NVP are known, many variables regarding etiology and treatment remain to be examined. Some contradictions in the published literature exist. This review helps to lay out these issues. The principles of associative learning and the study of cultural factors hold promise in offering insight into the origin of the aversions and its maintenance or reduction.

Statement of Competing Interests

The authors have no competing interests.
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