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The Effects of Face Masks on Facial Emotion Detection and Word Identification

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Abstract

During the global pandemic, individuals are advised to wear face masks as preventive action against COVID-19. This study explores the effects of face masks on verbal and nonverbal communication. Previous research suggests that obstruction of visual cues can hinder the identification of spoken words and the recognition of emotions. More specifically, previous studies show that covering the lower part of the face impairs the recognition of anger, joy, and sadness. Prior research was conducted using static facial expressions, but the present study used dynamic facial expressions that allow for constant monitoring of changes in facial expressions. Moreover, this study used two types of words, words that are part of a minimal pair and words that are not part of a minimal pair, to investigate to what extend face masks also impair word identification. A total number of 120 participants took part in the present study. First, participants were exposed to videos of actors, with or without a face mask, displaying facial expressions of anger, joy, sadness, fear, or neutral emotions and were asked to identify the emotion in each video. The results show that face masks impair the detection of sadness and fear. Furthermore, the results show that face masks did not influence the perception of neutral facial expressions and perhaps even enhanced the recognition of joy. Secondly, participants were exposed to videos of actors, with or without a face mask, pronouncing two types of words, words that are part of a minimal pair and words that are not part of a minimal pair, and were asked to identify the word being pronounced. The results show that face masks hinder the ability to identify words that are part of a minimal pair. These findings confirm the prediction that face masks hinder verbal and nonverbal communication. These insights inform people about the influence of face masks on social interactions. Individuals should thus carefully express their emotions and pay close attention to articulating words for the receiver to understand. Future research may focus on the effects of face masks in a conversational setting.

Keywords: *face masks, verbal communication, nonverbal communication, emotion detection, word identification*

Introduction

In December 2019, the Coronavirus Disease 2019 (COVID-19) was first identified in Wuhan, China (Cheng et al., 2020). The virus can be highly contagious and caused a global pandemic, with - as of February 2021 – more than 100 million global infections and more than 2.4 million deaths (COVID-19 Dashboard, 2020; Parvin et al., 2020; Spitzer, 2020). Symptoms of COVID-19 include high fever, dry cough, shortness of breath, pneumonia, fatigue, sore throat, runny nose, stomach problems, loss of taste or smell, headaches, vomiting, and diarrhea. The virus makes 6% of the infected individuals seriously ill, and in 14% of the cases, the symptoms are severe (Parvin et al., 2020). COVID-19 is transmitted between individuals via tiny respiratory droplets, ejected when speaking, coughing, or sneezing. Transmission usually takes place between individuals who are in close contact, within about two meters. Furthermore, COVID-19 can be transmitted by pre-symptomatic and asymptomatic individuals (Güner et al., 2020; Howard et al., 2020; Parvin et al., 2020).

At the beginning of 2020, the WHO declared the COVID-19 pandemic an international health emergency, urging all countries to take measures in order to detect infections and preventing spread (Güner et al., 2020). As a result, governments worldwide constructed guidelines for social distancing, hygiene, face masks, and quarantine to prevent the spread of the virus (Parvin et al., 2020). Globally, over a hundred countries advised individuals to cover their faces when they leave home or legally implemented mandatory wearing of face masks in public places as preventive action against COVID-19 (Rab & Javiad, 2020). Mitze et al. (2020) showed that the introduction of mandatory face masks helped reduce the spread of COVID-19 in Jena, a city in the east of Germany. These findings are supported by many other studies (Howard et al., 2020; Spitzer, 2020).

Although face masks have positive effects on preventing the spread of COVID-19, as shown in Figure 1, covering the lower half of the face can potentially have social and behavioral consequences (Betsch et al., 2020; Spitzer, 2020). For example, miscommunication can occur due to a reduced understanding of speech or misinterpretation of emotions caused by part of the face being visually obstructed by a face mask (Betsch et al., 2020; Langbehn et al., 2020; Roberson et al., 2012; Spitzer, 2020). Therefore, the current study explores the effects of wearing face masks on communication.

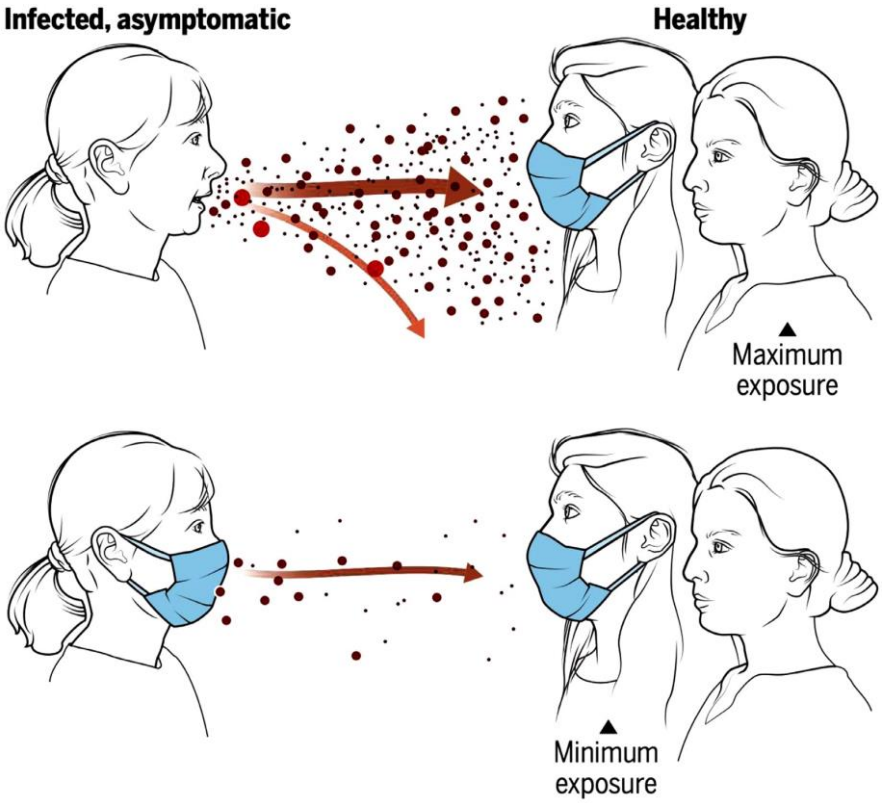

Figure 1. *The effect of facial masks on the spread of a virus (Spitzer, 2020).*

Theoretical Framework

As a prevention measurement against COVID-19, governments worldwide have implemented voluntary or mandatory policies concerning wearing face masks. Although face masks can help reduce the spread of the virus, they can also have adverse effects on communication. Face masks can impair the perception of verbal communication and nonverbal communication, such as facial expressions (Schögl & Jones, 2020; Spitzer, 2020). In the following, an overview of previous research on face masks and their potential effects on verbal and nonverbal communication is given. Literature concerning partial face covering is still limited, though this topic is exceptionally relevant due to the current pandemic concerning daily face-to-face interactions.

Effects of face masks on nonverbal communication

Communication consists of verbal and nonverbal behavior, where nonverbal communication is often defined as the silent form of communicating; without the use of words (Phutela, 2015). However, defining nonverbal communication as everything but words does not do justice to the complexity of the relationship between verbal and nonverbal behavior. Namely, the relationship between verbal and nonverbal behavior impacts the thought and language processes of the sender and the inferences drawn by the perceiver (Hall et al., 2019). In order to understand conveyed meanings, nonverbal and verbal behaviors often have to be considered together. For example, a large body of research shows that hand gestures produced during speech are part of an integrated speech production system (Goldin-Meadow & Alibali, 2013).

Nonverbal communication plays an essential role in communication, as research shows that a great deal of communication is nonverbal, and experts estimate that in any social situation, at least 65% of the message is nonverbally transferred (Allen, 1999). As shown in Table 1, nonverbal communication can consist of a variety of different behaviors.

Table 1. *Nonverbal behaviors (Duncan, 1969).*

Type	*Explanation*
Body motion or kinesic behavior	Gestures and other body movements; facial expression, eye movement, and posture
Paralanguage	Voice qualities, speech non-fluencies, and nonlanguage; laughing, yawning, and grunting
Proxemics	Use of social and personal space
Olfaction	Sense of smell
Skin sensitivity	Touch and temperature
Artifacts	Dress and cosmetics

Wearing facial masks and hereby covering the lower part of the face can influence nonverbal communication, particularly the perception of facial expressions. The face is often considered a canvas on which people communicate their emotional states and from which they can infer the emotional state of others (Darwin, 1965; Porter & ten Brinke, 2008). Spitzer (2020, p. 4) even defines the face as "one of the richest and most powerful tools in human communication". From the face, observers can quickly and easily make several inferences, namely about identity, gender, sex, age, race, ethnicity, sexual orientation, physical health, attractiveness, emotional state, personality traits, pain or physical pleasure, deception, and even social status (Spitzer, 2020). Thus, facial expressions are essential for communication, in particular, to convey the emotional state of others (Darwin, 1965; Porter & ten Brinke, 2008).

Facial expressions can be defined as temporary changes in the simple geometry of the face (Cattaneo & Pavesi, 2014). As mentioned before, by using these facial expressions, people can communicate emotional states. Many emotional states exist, but this study focuses on four basic emotions: anger, joy, sadness, and fear. Seminal studies have found that these primary emotions and their corresponding facial expressions are recognized across different cultures (Eibl-Eibesfeldt, 1970; Ekman and Friesen, 1975; Huber, 1931; Izard, 1971). With the help of the Facial Action Coding System (FACS), previous work determined which facial muscles are involved in the formation of each of the facial expressions of the basic emotions (Ekman and Friesen, 1975; Ekman and Friesen, 1978; Gosselin et al., 1997; Huber, 1931; Plutchik, 1962). The Facial Action Coding System (FACS) is a comprehensive and widely used method to objectively describe the facial activity (Ekman & Friesen, 1978).

In Figure 2, the four basic emotions and a neutral facial expression are displayed, as incorporated in the study by Calvo et al. (2012). The joy expression is described in the classic study

by Ekman and Friesen (1975) as a facial expression of tense lower eyelids, raised cheeks, and lip corners pulled up. Prior studies found that not seeing the bottom half of the face hinders the ability to recognize positive emotions, such as joy, due to the critical role of the mouth (Eisenbarth & Alpers, 2011; Fischer et al., 2012; Kotsia et al., 2008). These findings suggest that face masks may harm positive social interactions and the ability to understand or empathize with a conversational partner by not recognizing facial expressions of joy (Spitzer, 2020).

Figure 2. *Four basic facial expressions of emotion, accompanied by a neutral facial expression (Calvo et al., 2012).*

Ekman and Friesen (1975) described facial expressions of sadness as raised and drawn together inner eyebrows and lip corners pulled down. Furthermore, Ekman and Friesen (1975) described facial expressions of anger as lowered drawn-together eyebrows, tense lower eyelids, pressed lips, or lips parted in a square shape. Lastly, Ekman and Friesen (1975) described facial expressions of fear as raised and drawn together eyebrows, wide-open eyes with tense lower eyelids, and stretched lips. In comparison to positive emotions, Bombari et al. (2013) found that the eyes are more relevant for the facial expression of anger, fear, and sadness. Nonetheless, the facial expressions of anger, fear, and sadness all also include visual information expressed with the mouth. Thus, covering the mouth could potentially influence the perception of these emotions as well. Carbon (2020) investigated the impact of face masks on the readability of emotions, using six different static expressions. Participants in this study were asked to assess the emotional expressions of twelve different static faces, either with or without a face mask (Carbon, 2020). Overall, the findings by Carbon (2020) indicate that emotion detection was firmly reduced by face masks for facial expressions of anger, joy, and sadness.

Carbon (2020) found that the recognition was not impaired by covering the mouth area for neutral expressions. However, many emotional states such as joy, sadness, and anger were misinterpreted as neutral. Thus, the actual emotional state was not perceived anymore. Grahlow et

al. (2021, preprint) investigated whether emotion recognition was impaired by face masks, and found that emotion recognition was indeed impaired by the presence of face masks, especially for the anger and sadness emotions. However, for neutral and joy facial expressions, the findings by Grahlow et al. (2021, preprint) did not show a significant reduction of emotion recognition.

Like the studies by Carbon (2020) and Grahlow et al. (2021, preprint), most previous studies on facial expressions of emotion were conducted using static facial expressions, such as photo material. Nonetheless, the use of static facial expressions in emotion recognition is recently being questioned (Roark et al., 2003). In daily social interactions, the temporal aspects of facial motion are essential. Therefore, to improve the ecological validity of previous studies, dynamic facial expressions are recommended by several studies (Alves, 2013; Ambadar et al., 2005).Fiorentini and Viviani (2011) state that static facial expressions are a poor representation of reality since facial expressions are inherently dynamic. Moreover, a study by Sato and Yoshikawa (2007) emphasizes that the interpretation of emotions depends on the constant monitoring of changes in facial expressions that occur from moment to moment. Lastly, neuroimaging studies found that dynamic facial expressions evoke more brain activity in areas associated with interpreting social signals and processing of emotions (Arsalidou et al., 2011) and produced faster responses in visual areas than static facial expressions (Recio et al., 2011). Therefore, the often-used standardized photographs created by Ekman and Friesen (1976) are recently being replaced by sets of dynamic expressions such as the Amsterdam Dynamic Facial Expression Set – ADFES (Van der Schalk et al., 2011). This study will use the Amsterdam Dynamic Facial Expression Set – ADFES (Van der Schalk et al., 2011) to explore the effects of face masks on detecting emotions, hereby improving the ecological validity and incorporating constant monitoring of changes in facial expressions.

Effects of face masks on verbal communication

Face masks do not only affect nonverbal communication but covering the lower part of the face can have detrimental effects on verbal communication as well. Verbal communication may be affected due to the obstruction of visual signals or damped sound amplitude (Spitzer, 2020). The current study excludes the effects of face masks on sound quality and will solely investigate whether the obstruction of visual signals hinders verbal communication.

Speech is generally considered within the auditory domain only, and people do not realize that visual signals support speech understanding (Spitzer, 2020; Worster et al., 2018). People tend to look closely at the mouth of their conversational partner in circumstances of impaired sound comprehensibility (Spitzer, 2020). Visual information or visual speech are essential aspects for guiding and enhancing speech perception (Lusk & Mitchel, 2016; Mitchel & Weiss, 2014; Sumby

& Pollack, 1954; Worster et al., 2018). The obstruction of visual signals from the lips could be a detrimental effect of face masks on verbal communication, as it appears that the visual information for word identification is primarily obtained from the lower part of the face (Worster et al., 2018).

The McGurk effect is an excellent example of how visual cues influence what is heard (Atcherson et al., 2017). McGurk and McDonald (1976) showed that if the visual and auditory combination is inconsistent, the perceived utterance differs from both the visual and the auditory input. For example, the utterance /da/ would be perceived when a simultaneous combination of an auditory /ba/ and a visual /ga/ is provided. The fact that visual cues influence what is heard raises questions about whether the lack of visual information due to face mask-wearing could have similar effects.

Thus, the lack of visual information due to face masks could potentially influence speech understanding, for example, word identification. Lack of visual cues could create difficulties when distinguishing words that differ on a single phoneme, toneme, or chroneme, otherwise known as minimal pairs. In minimal pairs, visual cues could help if the distinctive phoneme is pronounced visually differently. In Dutch, there is a visual difference between bilabials ([p], [b], and [m]) and velars ([k], [g], and [ŋ]). Bilabials are produced with two lips against each other, whereas velars are produced with two lips apart (International Phonetic Association & International Phonetic Association Staff, 1999). Moreover, when pronouncing velars, the tongue is in the back of the mouth, touching the soft palate, a position that provokes visibility of teeth.

If a person wears a face mask, the mouth is completely covered, and people can solely depend on the auditory utterance. No prior research explored a potential relation between face covering and miscommunication due to the lack of visual input. However, due to COVID-19, daily face-to-face conversations increasingly involve face covering. Thus, it is exceptionally relevant to explore whether face masks provoke miscommunication due to the lack of visual input. Therefore, this study will explore if face masks have detrimental effects on word identification. Additionally, this study will explore whether these detrimental effects are more substantial for words that are part of a minimal pair (and can thus be easily confused for another word) compared to words that are not part of a minimal pair.

Hypotheses and research question

The theoretical overview presented above illustrates that face masks, covering the lower half of the face, could have detrimental effects on verbal and nonverbal communication. An aspect of nonverbal communication that could be affected by face masks is the perception of emotional states. The facial expressions of emotions such as joy, sadness, anger, or fear all include visual

information expressed using the mouth, which is obstructed by face masks. However, we do not know to what extent face masks impair emotion detection. Namely, prior research incorporated static facial expressions instead of dynamic facial expressions that allow for constant monitoring of changes in facial expressions.

Additionally, an aspect of verbal communication that could be affected by face masks is the ability to identify words. Namely, the visual information used for word identification is primarily obtained from the lower half of the face. In minimal pairs (i.e., sets of words which only differ on one phoneme), the auditory information of words is relatively similar, and visual cues could enhance word identification if the distinctive phoneme is pronounced visually differently. However, we do not know to what extent face masks impair word identification due to a lack of prior research.

The theoretical framework above leads to the following research question: To what extent do face masks influence the ability to detect emotions and identify words?

Based on Carbon (2020), indicating that face masks impair emotion detection, the following hypothesis is formulated:

H1: Covering the lower half of the face results in impaired recognition of all four basic emotions (joy, sadness, anger, and fear) compared to not covering the lower half of the face.

Based on Carbon (2020), indicating that face masks did not impair the detection of neutral facial expressions, the following hypothesis is formulated:

H2: Covering the lower half of the face does not result in impaired recognition of a neutral expression.

Based on Eisenbarth and Alpers (2011), Fischer et al. (2012), and Kotsia et al. (2008), indicating the importance of the mouth for facial expressions of joy, the following hypothesis is formulated:

H3: Covering the lower half of the face results in impaired recognition of the joy emotion to a greater extent than the other emotions (anger, fear, and sadness).

Based on Carbon (2020), indicating that face masks result in misinterpretation of joy, sadness, and anger as neutral, the following hypothesis is formulated:

H4: Covering the lower half of the face results in emotional states such as joy, sadness, fear, and anger being misinterpreted as neutral

Based on Worster et al. (2018), indicating that visual information for word identification is primarily obtained from the lower part of the face, the following hypotheses are formulated:

H5: Covering the lower half of the face results in impaired word identification compared to not covering the lower half of the face.

H6: Covering the lower half of the face results in impaired word identification for words that are part of a minimal pair to a greater extent compared to words that are not part of a minimal pair.

Methodology

The hypotheses of this study were tested through two separate experiments. Due to the importance of the position of the mouth in facial expressions of emotion and the fact that speech would influence this position, speech and emotions cannot be tested in the same experiment. In addition, when speaking, the mouth is forced to move, which might negatively affect the uniqueness of the facial expressions of emotions. Therefore, experiment A tested the first, second, third, and fourth hypotheses, and experiment B tested the fifth and sixth hypotheses.

Experiment A

Materials

Experiment A included two independent variables, namely *face masks* and *emotions*. The independent variable face masks consisted of two levels; wearing a face mask and not wearing a face mask. The independent variable emotions consisted of five levels; joy, sadness, anger, fear, and neutral.

The video material of the Amsterdam Dynamic Facial Expression Set – ADFES (Van der Schalk et al., 2011) was obtained and manipulated to operationalize the independent variables. As the Netherlands, where this study took place, is a North European country, the video set included North European actors. The video set derived from the ADFES consisted of fifty videos, including ten different actors equally divided by gender; five male and five female actors. Each actor visually displayed each of the five emotional states; joy, sadness, anger, fear, and neutral. The duration of each video was six seconds.

Manipulations to the original videos, hence fifty additional videos, were made in order to operationalize the independent variable *face masks*. As shown in Figure 3, these videos included the same actors. However, a surgical face mask was edited into the videos to cover the lower half of the face. Additionally, as shown in Figure 3, the videos did not include the whole body of the actor, solely a portrait shot from the shoulders up.

All videos were entered into the Qualtrics survey. However, each participant was only exposed to a random selection of twenty out of the fifty videos. This random selection differed per participant, however it always included each emotion four times, and was always equally divided between male and female actors.

Figure 3. *Screenshot of an original video (left) and a screenshot of the manipulated video (right) of an actress expressing joy (Van der Schalk et al., 2011).*

Subjects

To effectively measure the effects of face masks on emotion detection, a total of 120 participants were recruited for this experiment by use of snowball sampling. The participants were all Dutch native speakers aged between 18 and 71 (M = 37.15, SD = 15.99). A one-way ANOVA showed no significant difference in age between the experimental group, exposed to videos including face masks, and the control group, exposed to videos without face masks (F (1) = 1.81, p = .180). The 120 participants consisted of 74 males (61.7%), 45 females (37.5%), and 1 participant that did not indicate their gender (0.8%). A chi-square test showed no significant difference in gender distribution between the experimental and control groups (X^2 (2) = 1.37, p = .505). A total of 25 participants had a Master Degree (20.8%), 31 participants had a Bachelor Degree (25.8%), 30 participants attended University or University of Applied Sciences but had no degree yet (25.0%), 33 participants had a high school or comparable degree (27.5%), and 1 participant had no high school degree (0.8%). A chi-square test showed no significant difference in the distribution of educational level between the experimental and control groups (X^2 (4) = 2.18, p = .702).

Experimental design

The design of this study is a 5x2 mixed design, with the independent variable *face masks* as a between-subject factor and the independent variable *emotions* as a within-subject factor. The between-subject factor consisted of two levels; wearing a face mask or not wearing a face mask. The within-subject factor consisted of five levels; joy, sadness, anger, fear, and neutral.

Instruments

This experiment included one dependent variable, namely *emotion detection*. The dependent variable was tested using the answers to a multiple-choice question. After watching each video,

participants were asked which emotion they perceived. When answering this question, participants had to choose between five options; joy, sadness, anger, fear, or neutral. Correct answers were coded as ‘1’, and incorrect answers were coded as ‘0’. For each participant, the correct scores per emotion were added up. Thus, the number of correct answers out of four (because each emotion was shown 4 times) were used in the analyses.

In order to test the fourth hypothesis, a duplicate data set was created, and misinterpretations of joy, sadness, fear and anger as neutral were coded as '1'. All other answers were coded as '0'. For each participant, the false neutral scores per emotion were added up. Thus, the number of misinterpretations as neutral for each of the emotions was used in the analyses.

Procedure

Participants received a link to the experiment that was conducted via an online survey platform called Qualtrics. First, participants were presented with an explanation of the experiment and the terms and conditions. Once the participants agreed to the terms and conditions, they continued by filling in demographical information. After the participants filled in the questions concerning demographics, they continued to start with the experiment. The participants were exposed to twenty videos, each emotion four times in a random order, in either one of the two face mask conditions. After each video, the participants answered the following question:

Which of the following emotions did you perceive?

a. Joy c. Anger e. Neutral

b. Sadness d. Fear

Once the participants had answered all twenty questions, they continued with experiment B.

Statistical treatment

In order to examine the differences in emotion detection between the two face mask conditions (hypothesis one, two, and three), a repeated measures analysis of variance was conducted using SPSS. A repeated measures analysis of variance was conducted with *face masks* as between-subject variable, *emotions* as within-subject variable, and *emotion detection* as dependent variable.

Moreover, to test the fourth hypothesis, a repeated measures analysis of variance was conducted with *face masks* as between-subject variable, *emotions* as within-subject variable, and false neutral scores as dependent variable.

Experiment B

Materials

Experiment B included two independent variables, namely *face masks* and *words*. The independent variable *face masks* consisted of two levels; wearing a face mask and not wearing a face mask. The independent variable *words* consisted of two levels; words that are part of a minimal pair and words that are not part of a minimal pair.

The video material in experiment B was not the same as in experiment A. Thirty-two videos were produced to operationalize the independent variables. The videos included four different actors, equally divided by gender; two male and two female actors. As the Netherlands, where the current study took place, is a North European country, the videos included North European actors. All actors pronounced four Dutch words that are part of a minimal pair and four words that are not part of a minimal pair. Each actor pronounced a different set of words. Each video included the pronunciation of 1 word.

Manipulations to the above-mentioned videos, thus thirty-two additional videos were made to operationalize the independent variable *face masks*. Similar to experiment A, these videos included the same actors, and identical sound. However, a surgical face mask was edited into the video to cover the lower half of the face.

As shown in Appendix A, the words used in the videos are Dutch words, sixteen words that are part of a minimal pair (so eight minimal pairs) and sixteen words that are not part of a minimal pairs. The words that are part of a minimal pair were words that differ from another existing word on a single phoneme. More specifically, the words differed so that the distinguishing phoneme was either a bilabial or a velar, due to the differences in production and visual cues of the mouth. As mentioned earlier, bilabials are produced with two lips against each other. In contrast, velars are produced with two lips apart and the tongue in the back of the mouth, which provokes teeth visibility.

All videos were entered into the Qualtrics survey. However, each participant was only exposed to a random selection of twenty videos. This random selection differed per participant, however it always included an equal number of words that are part of a minimal pair and words that are not part of a minimal pair, and was always equally divided between male and female actors.

Subjects

Experiment B immediately followed after experiment A in the same Qualtrics survey. Hence, the participants were the same as in experiment A. Participants in the experimental group in experiment A were also in the experimental group in experiment B, exposed to videos including face masks. Similarly, participants in the control group in experiment A were also in the control group in experiment B, exposed to videos without face masks.

Experimental Design

The design of this study is a 2x2 mixed design, with the independent variable *face masks* as a between-subject factor and the independent variable *words* as a within-subject factor. The between-subject factor consisted of two levels; wearing a face mask or not wearing a face mask. The within-subject factor consisted of two levels; words that are part of a minimal pair and words that are not part of a minimal pair.

Instruments

This study included one dependent variable, namely *word identification*. The dependent variable was tested using the answers to a single open question. After watching each video, participants were asked what word they had heard, and to write this word down in the appropriate text field. Correct answers were coded as ‘1’, and incorrect answers were coded as ‘0’. Each answer coded as incorrect was individually examined. A shown in Table 2, if the incorrect answer was considered an obvious spelling error or typo, it’s coding was changed to correct, as ‘1’. Moreover, as shown in Table 2, if the incorrect answer was phonetically almost identical as the correct answer, the answer was coded as correct, as '1'. The last only occurred with the target words *lap* and *eb*, as in Dutch these words are phonetically almost identical to *lab* and *app*, which they were sometimes (ten times in total) identified as.

Table 2. *Examples of false answers coded as correct; ‘1’.*

Reason	*False answer*	*Correct answer*	*Number of cases*
Spelling error	Cigaar	Sigaar	5
Typo	Ritmr	Ritme	1
Phonetics	Lab	Lap	10

For each participant, the number of correct scores per word type were added up. Thus, the number of correct answers (out of 10) were used in the analyses.

Procedure

Participants that entered experiment A continued with experiment B in the same survey within Qualtrics. The order was the same for each participant, first experiment A, then experiment B. First, participants were presented with an explanation of the experiment, and after reading the instructions, they continued to start the experiment. The participants were exposed to twenty randomly ordered and selected videos, equally divided between videos including words that are part of a minimal pair and words that are not part of a minimal pair, in either one of the two face mask conditions. After each video, the participants answered the following question: “What word did you hear?”. When all twenty questions were answered, the participants could end the survey and close the window. The participants' data were collected anonymously, and the complete experiment (experiment A and B together) took approximately ten minutes.

Statistical treatment

In order to examine the differences in word identification between the two face mask conditions, a repeated measures analysis of variance was conducted using SPSS. A repeated measures analysis of variance was conducted with *face masks* as a between-subject variable, *words* as within-subject variables, and *word identification* as dependent variable.

Results

Experiment A

Effect of face masks and emotion type on emotion detection

Descriptives (see Table 3) showed that, overall, participants were mostly able to detect to correct emotions in both face mask conditions. However, a repeated measures analysis for emotion detection with emotions as within-subject factor and face masks as between-subject factor showed a significant main effect of emotions (F (4, 472) = 3.90, p = .004) on emotion detection. All means and standard deviations for emotion detection are displayed in Table 3. The emotion detection for sadness (M = 3.39, SD = 0.61) was lower than for anger (p = .022, Bonferroni- correction; M = 3.63, SD = 0.05), for joy (p = .048, Bonferroni- correction; M = 3.59, SD = 0.05), and for neutral (p = .006, Bonferroni- correction; M = 3.64, SD = 0.06). There was no difference between the detection of sadness and fear (p = .469, Bonferroni- correction; M = 3.54, SD = 0.05). There was no difference between the detection of joy and the detection of fear (p = 1.00, Bonferroni- correction), anger (p = 1.00, Bonferroni- correction), and neutral (p = 1.00, Bonferroni- correction). There was no difference between the detection of anger and the detection of fear (p = 1.00, Bonferroni- correction) and neutral (p = 1.00, Bonferroni- correction). There was no difference between the detection of fear and neutral (p = 1.00, Bonferroni- correction).

Moreover, a repeated measures analysis for emotion detection with emotions as within-subject factor and face masks as between-subject factor showed a significant main effect of face masks (F (1, 118) = 38.55, p < .001) on emotion detection. The emotion detection for participants exposed to videos including face masks (M = 3.38, SD = 0.04) was lower than for participants exposed to videos not including face masks (M = 3.73, SD = 0.04).

These main effects were qualified by a significant interaction effect between emotions and face masks (F (4, 472) = 18.54, p < .001), as visualized in Figure 4.

Table 3. *Means and standard deviations (between brackets) for emotion detection (number of answers correct out of 4).*

Emotion	*Emotion detection*					
	Face mask		No face mask		Total	
Anger	3.49 (.644)	N = 51	3.74 (.504)	N = 69	3.63 (.579)	N = 120
Joy	3.71 (.502)	N = 51	3.48 (.532)	N = 69	3.58 (.529)	N = 120
Sadness	3.02 (.812)	N = 51	3.75 (.526)	N = 69	3.44 (.754)	N = 120
Fear	3.12 (.739)	N = 51	3.96 (.205)	N = 69	3.60 (.653)	N = 120
Neutral	3.57 (.700)	N = 51	3.71 (.571)	N = 69	3.65 (.630)	N = 120
Total	3.38 (.042)	N = 51	3.73 (.036)	N = 69		

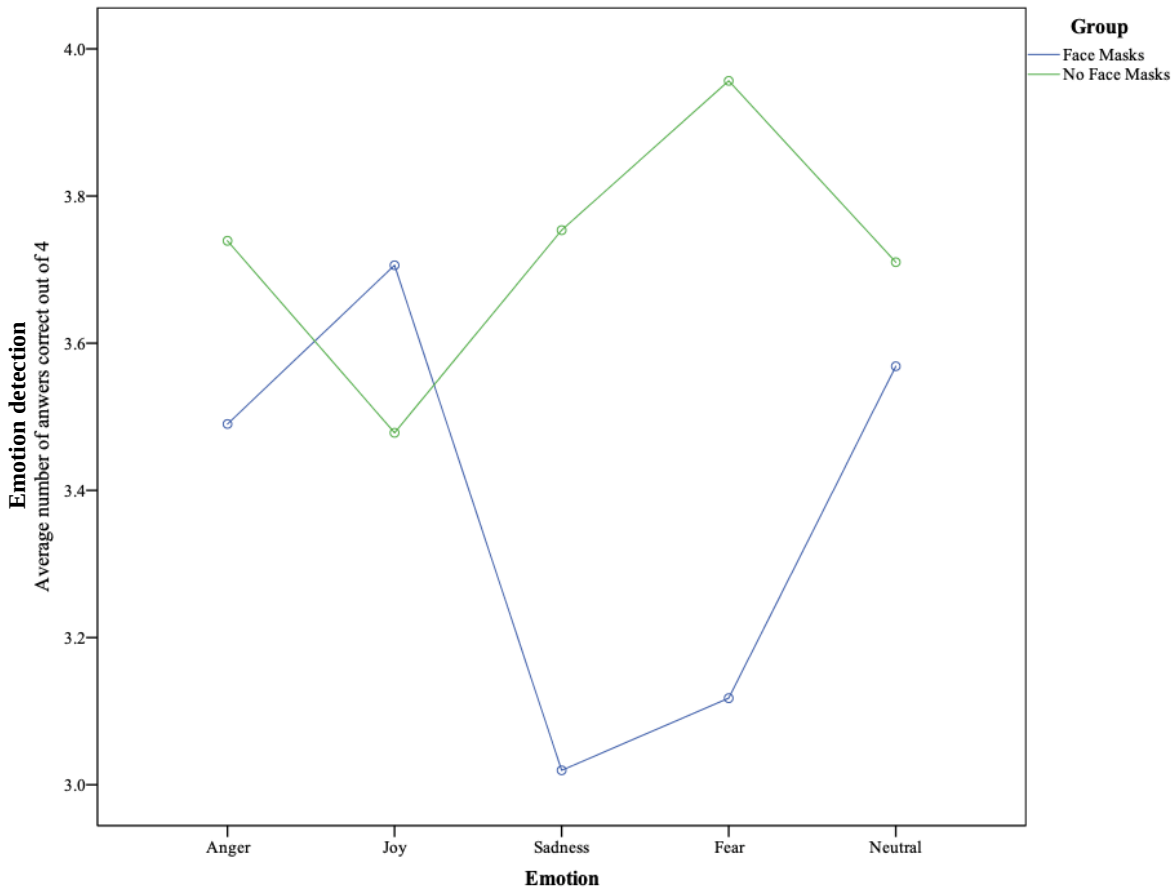

Figure 4. *A visualization of the interaction between emotions and face masks.*

Follow up analyses showed that differences between the five types of emotions were found among subjects exposed to videos with face masks (F (4, 200) = 10.31, p < .001). The detection of anger (M = 3.49, SD = 0.64) was higher for participants exposed to videos including face masks than the detection of sadness (p = .008, Bonferroni- correction; M = 3.02, SD = 0.81). The detection of joy (M = 3.71, SD = 0.50) was higher for participants exposed to videos including face masks than the detection of sadness (p < .001, Bonferroni- correction) and fear (p < .001, Bonferroni- correction; M = 3.12, SD = 0.74). The detection of neutral (M = 3.57, SD = 0.70) was higher for participants exposed to videos including face masks than the detection of sadness (p < .001, Bonferroni- correction) and fear (p = .020, Bonferroni- correction). There was no difference between the detection of anger and the detection of joy (p = .623, Bonferroni- correction), fear (p = .104, Bonferroni- correction), and neutral (p = 1.00, Bonferroni- correction). There was no difference between the detection of joy and neutral (p = 1.00, Bonferroni- correction). There was no difference between the detection of sadness and fear (p = 1.00, Bonferroni- correction).

Follow up analyses also found differences between the five types of emotions among subjects exposed to videos without face masks (F (4, 272) = 9.49, p < .001). The detection of fear (M = 3.96, SD = 0.21) was higher for participants exposed to videos without face masks than the detection of anger (p = .013, Bonferroni- correction; M = 3.74, SD = 0.50), joy (p < .001, Bonferroni- correction; M = 3.48, SD = 0.53), sadness (p = .023, Bonferroni- correction; M = 3.75, SD = 0.53), and neutral (p = 0.17, Bonferroni- correction; M = 3.71, SD = 0.57). The detection of joy was lower for participants exposed to videos without face masks than the detection of anger (p = .037, Bonferroni- correction) and sadness (p = .018, Bonferroni- correction). There was no difference between the detection of anger and sadness (p = 1.00, Bonferroni- correction). There was no difference between the detection of neutral and the detection of anger (p = 1.00, Bonferroni- correction), joy (p = .125, Bonferroni- correction), and sadness (p = 1.00, Bonferroni- correction) among participants exposed to videos without face masks. Thus, face masks impaired the detection of all emotions except joy, and impaired the detection of sadness and fear to the greatest extend compared to other emotions.

Effect of face masks and emotion type on wrongful detections of neutral

Descriptives (see Table 4) showed that, overall, there were few wrongful detections of neutral emotions in either of the face mask conditions. However, a repeated measures analysis for false detections of neutral with emotions as within-subject factor and face masks as between-subject factor showed a significant main effect of emotions (F (3, 354) = 16.99, p < .001) on false detections of neutral. All means and standard deviations for wrongful detections of neutral are

displayed in Table 4. The wrongful detection of anger as neutral (M = 0.03, SD = 0.16) was lower than wrongful detection of sadness as neutral (p = .002, Bonferroni- correction; M = 0.14, SD = 0.37), wrongful detection of joy as neutral (p < .001, Bonferroni- correction; M = 0.31, SD = 0.48), and wrongful detection of fear as neutral (p < .001, Bonferroni- correction; M = 0.27, SD = 0.46). The wrongful detection of sadness as neutral was lower than wrongful detection of fear (p = .015, Bonferroni- correction) and joy as neutral (p = .040, Bonferroni- correction). The wrongful detection of fear as neutral was higher than wrongful detection of sadness as neutral. There was no difference between wrongful detections of fear as neutral and wrongful detections of joy as neutral (p = 1.00, Bonferroni- correction).

Moreover, a repeated measures analysis for false detections of neutral with false neutrals as within-subject factor and face masks as between-subject factor showed a significant main effect of face masks (F (1, 118) = 24.47, p < .001) on false detections of neutral. The wrongful detections of neutral emotions for participants exposed to videos including face masks (M = 0.28, SD = 0.03) was higher than for participants exposed to videos without face masks (M = 0.12, SD = 0.2).

These main effects were qualified by a significant interaction effect between emotions and face masks (F (3, 354) = 28.89, p < .001), as visualized in Figure 5.

Table 4. *Means and standard deviations (between brackets) for the wrongful detection of neutral emotions (number of false neutrals out of 4)* .

Emotion	*Wrongful detection of neutral emotions*					
	Face mask		No face mask		Total	
Anger	.04 (.196)	N = 51	.01 (.120)	N = 69	.03 (.157)	N = 120
Joy	.20 (.448)	N = 51	.39 (.492)	N = 69	.31 (.482)	N = 120
Sadness	.25 (.483)	N = 51	.06 (.235)	N = 69	.14 (.373)	N = 120
Fear	.63 (.528)	N = 51	.00 (.000)	N = 69	.27 (.463)	N = 120
Total	.28 (.025)	N = 51	.12 (.022)	N = 69		

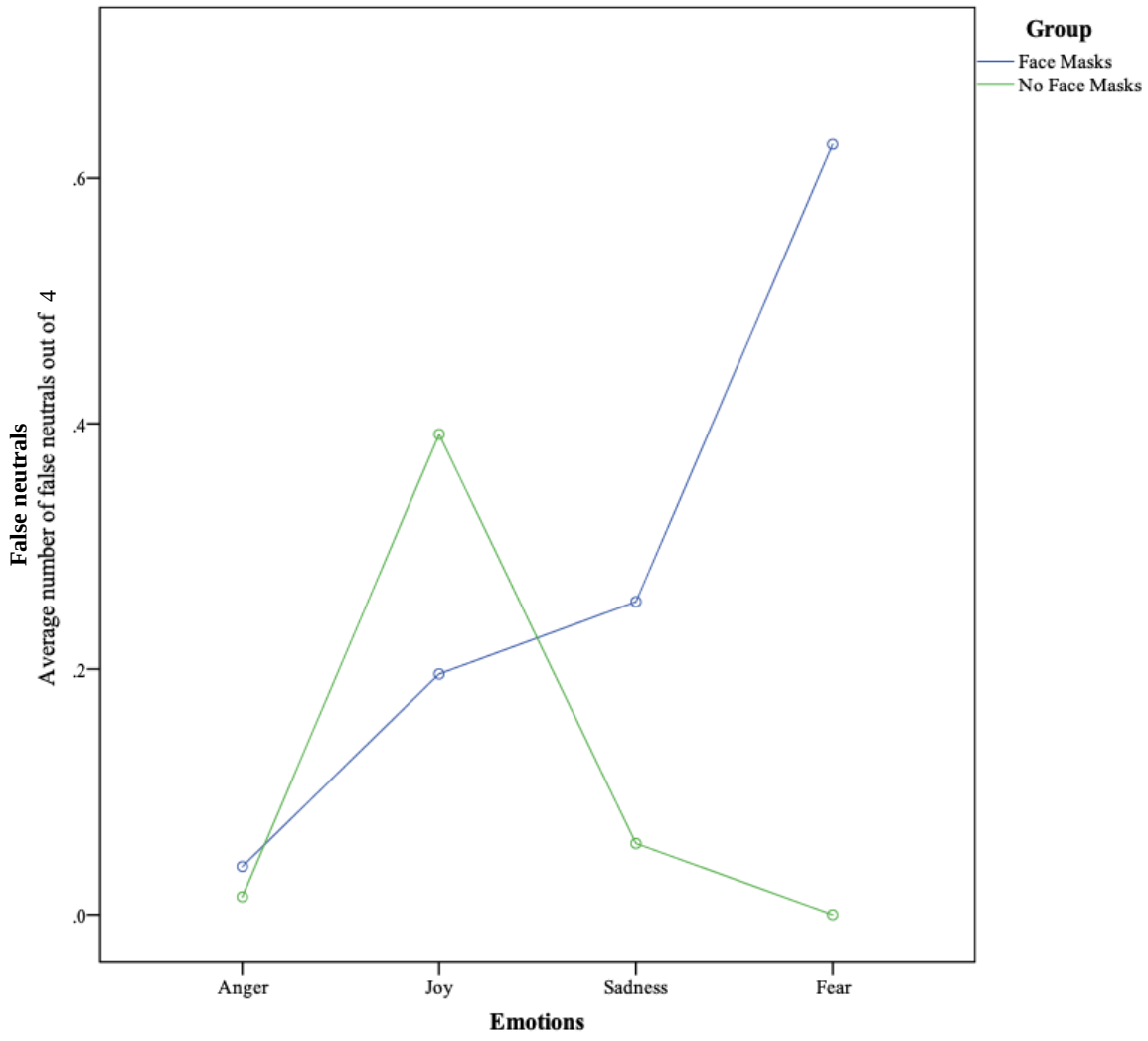

Figure 5. *A visualization of the interaction between false neutrals and face masks.*

Follow up analyses showed differences between the four types of false neutrals among subjects exposed to videos with face masks (F (3, 150) = 17.13, $p < .001$). The misinterpretation of fear as neutral (M = 0.63, SD = 0.53) was higher for participants exposed to videos including face masks than the misinterpretation of anger as neutral ($p < .001$, Bonferroni- correction; M = 0.04, SD = 0.20), the misinterpretation of sadness as neutral ($p = .010$, Bonferroni- correction; M = 0.25, SD = 0.48), and the misinterpretation of joy as neutral ($p < .001$, Bonferroni- correction; M = 0.20, SD = 0.45). The misinterpretation of sadness as neutral was higher for participants exposed to videos including face masks than the misinterpretation of anger as neutral ($p < .001$, Bonferroni-correction). There was no difference between wrongful detections of joy as neutral and wrongful detections of anger as neutral ($p = .116$, Bonferroni- correction), or sadness as neutral ($p = 1.00$, Bonferroni- correction) among participants exposed to videos including face masks.

Follow up analyses also showed differences between the four types of false neutrals among subjects exposed to videos without face masks (F (3, 204) = 30.37, p < .001). The misinterpretation of joy as neutral (M = 0.39, SD = 0.49) was higher for participants exposed to videos without face masks than the misinterpretation of anger as neutral (p < .001, Bonferroni- correction; M = 0.01, SD = 0.12), the misinterpretation of sadness as neutral (p < .001, Bonferroni- correction; M = 0.06, SD = 0.24), and the misinterpretation of fear as neutral (p < .001, Bonferroni- correction; M = 0.00, SD = 0.00). There was no difference of wrongful neutral detections between other emotion groups (all p > .268, Bonferroni- correction). Thus, face masks resulted in fewer misinterpretations of joy as neutral, and impaired the detection of fear to the greatest extend compared to other emotions.

Experiment B

Effect of face masks and word type on word identification

A repeated measures analysis for word identification with words as within-subject factor and face masks as between-subject factor showed a significant main effect of words (F (1, 118) = 49.43, p < .001) on word identification. All means and standard deviations for word identification are displayed in Table 5.

The identification of words that are not part of a minimal pair (M = 9.43, SD = 1.65) was higher than the identification of words that are part of a minimal pair (M = 8.57, SD = 1.61).

A repeated measures analysis for word identification with words as within-subject factor and face masks as between-subject factor also showed a significant main effect of face masks (F (1, 118) = 4.58, p = .034) on word identification. The word identification for participants exposed to videos including face masks (M = 8.68, SD = 0.20) was lower than for participants exposed to videos not including face masks (M = 9.24, SD = 0.17).

These main effects were qualified by a significant interaction effect between words and face masks (F (1, 118) = 13.48, p < .001), as visualized in Figure 6.

Table 5. *Means and standard deviations (between brackets) for word identification (number of correct answers out of 10).*

Word type	*Word identification*					
	Face mask		No face mask		Total	
Part of minimal pair	7.96 (1.61)	N = 51	9.01 (1.47)	N = 69	8.57 (1.61)	N = 120
Not part of minimal pair	9.39 (1.69)	N = 51	9.46 (1.64)	N = 69	9.43 (1.65)	N = 120
Total	8.68 (.199)	N = 51	9.24 (.171)	N = 69		

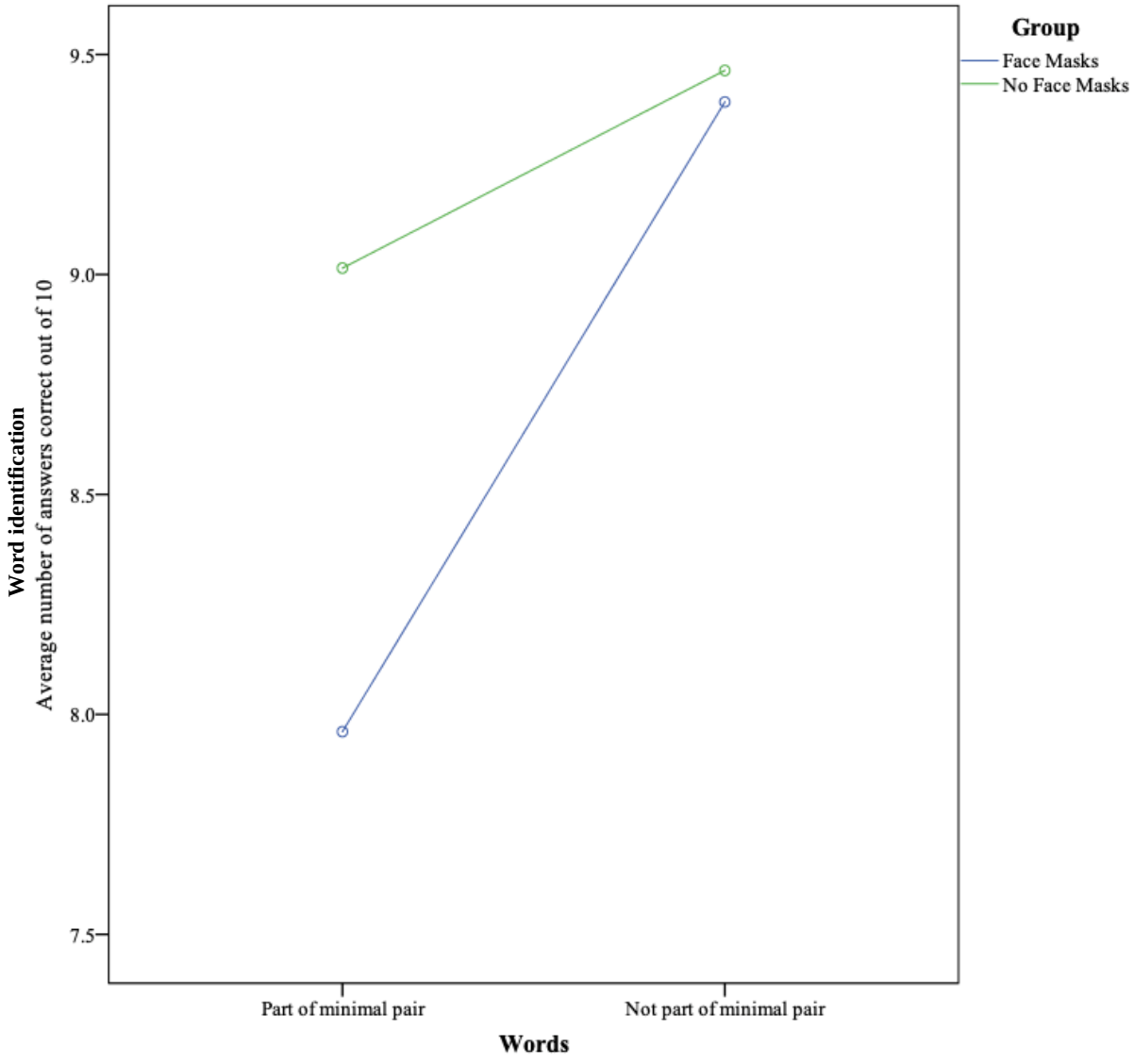

Figure 6. *A visualization of the interaction between words and face masks.*

Follow up analyses showed that the difference between the two types of words was found among subjects exposed to videos with face masks (F (1, 50) = 42.65, $p < .001$). The identification of words that are not part of a minimal pair (M = 9.39, SD = 1.69) was higher for participants exposed to videos including face masks than the identification if words that are part of a minimal pair (M = 7.96, SD = 1.61).

Follow up analyses showed that the difference between the two types of words was also found among subjects exposed to videos without face masks (F (1, 68) = 7.57, p = .008). The identification of words that are not part of a minimal pair (M = 9.46, SD = 1.64) was higher for participants exposed to videos including face masks than the identification of words that are part of a minimal pair (M = 9.01, SD = 1.47). Thus, even if the sound of the videos in both face masks condition are identical, words that are part of a minimal pair are more difficult to identify compared to words that are not part of a minimal pair. Moreover, this difference is especially amplified by the presence of face masks.

Conclusion and discussion

The present study was conducted to investigate the effects of wearing face masks on the perception of basic emotions and word identification. The participants of this study were exposed to videos with actors either wearing a face mask or not wearing a face mask. The actors in the videos of experiment A displayed facial expressions related to the following five basic emotions: joy, anger, sadness, fear, or neutral. The actors in the videos of experiment B pronounced two types of words. Namely, words that can be categorized as part of a minimal pair (words that differ from another word on one phoneme only), or words that are not part of a minimal pair (words that cannot change into another word by substituting a single phoneme).

The research question of the present study was: To what extent do face masks influence the ability to detect emotions and identify words? In short, to answer the research question, one can conclude that face masks impair the ability to detect emotions and to identify words. The research question was answered with the use of six hypotheses, presented in the following.

Effect of face masks and emotion type on emotion detection

The findings of experiment A reveal that wearing face masks indeed impairs emotion detection. Especially looking at the mean differences for the detection of the sadness and fear emotions, face masks seem to play an important role. For the other three emotions (anger, joy, and neutral) face masks do not seem to affect emotion detection to a similar degree.

Thus, the present study partly confirms the first hypothesis that covering the lower half of the face results in impaired recognition of all four emotions (joy, sadness, anger, and fear) compared to not covering the lower half of the face. Namely, there was an effect of face masks on emotion detection, and covering the lower half of the face resulted in impaired recognition of sadness and fear. On the other hand, face masks did not substantially affect the emotion detection of anger and joy.

The finding that the detection of fear was impaired by face masks is contradictory to the findings of Carbon (2020) that indicate that face masks did not reduce the recognition of the expression of fear. Carbon (2020) suggests that the detection of the expression of fear is not reduced because face masks do not cover the most critical indication of the expression of fear; the eyes. These findings are supported by Grahlow et al. (2021, preprint), as this study also did not find a significant reduction of the recognition of fear either when applying face masks. The present study's findings show that the detection of the expression of fear is impaired the most compared to the other

emotions by wearing face masks. The main difference between the present study and the studies by Carbon (2020) and Grahlow et al. (2021, preprint), is the use of dynamic and static material. The present study made use of dynamic video material in order to pursue more ecologically valid real-world conditions which allow for constant monitoring of changes in facial expressions whereas the previous studies by Carbon (2020) and Grahlow et al. (2021, preprint) made use of static material. Apparently, the dynamic aspect of emotions is decreasing the ability to detect fear when applying face masks.

The finding that the detection of sadness was reduced by the presence of face masks aligns with previous work by Carbon (2020) and Grahlow et al. (2021, preprint). As mentioned earlier, the studies by Carbon (2020) and Grahlow et al. (2021, preprint) experimented with static material instead of dynamic material as was done in the present study. In contrast with the present study, the findings of these studies additionally indicate that face masks hinder the ability to detect anger (Carbon, 2020; Grahlow et al., 2021, preprint) and joy (Carbon, 2020). Therefore, one could speculate that dynamic movements are more important to detect both anger and joy compared to fear. Further research should be conducted in order to investigate the importance of dynamics with regard to the detection of emotional states.

These findings indicate that face masks could be detrimental to the conveyance of emotional states, potentially leading to miscommunication. Moreover, these findings show that the hinder from face masks differs between the type of emotion that is conveyed. Indeed, the findings of experiment A reveal that emotion type influences emotion detection. Findings show that overall (i.e., for both face mask conditions), the detection of the sadness emotion was lower compared to the anger, joy, and neutral emotions.

By exploring the interaction between emotion type and face masks, the results of experiment A reveal that for participants exposed to videos including face masks the detection of the joy, anger, and neutral emotions was higher compared to the detection of the sadness emotion. Moreover, the detection of the joy and neutral emotions was higher compared to the detection of the fear emotion. On the other hand, for participants exposed to videos without face masks the detection of the fear emotion was higher compared to all of the other emotions (anger, joy, sadness, and neutral). Moreover, the detection of the joy emotion was lower compared to the detection of the anger and sadness emotions. In conclusion, face masks seem to impair the detection of the sadness and fear emotion to a greater extend compared to the other emotions (anger, joy, and neutral).

The second hypothesis of this study suggested that covering the lower half of the face does not result in impaired recognition of a neutral expression. The findings of experiment A reveal that wearing face masks indeed does not impair the detection of neutral emotions, confirming the

hypothesis. Looking at the mean differences of the present study, face masks influenced the perception of the neutral emotion the least compared to all other emotions. This finding is in line with previous research (Carbon 2020; Grahlow et al., 2021, preprint). Again, the only difference between the present study and the studies by Carbon (2020) and Grahlow et al. (2021, preprint) is the use of dynamic material instead of static material. Nonetheless, in all videos of the present study the starting position of the actors was a neutral facial expression. Hence, no change in facial expression (or barely any other movement) was present in the videos testing for the detection of neutral emotions.

Lastly, the findings of experiment A reveal that wearing face masks does not impair the detection of the joy emotion. Therefore, the present study rejects the third hypothesis that covering the lower half of the face results in impaired recognition of the joy emotion to a greater extent than the other emotions (anger, fear, and sadness). The present study found the opposite as the detection of joy was least impaired by the presence of face masks compared to the other emotions. Even more so, the descriptives of this study suggest that face masks may not hinder, but may even facilitate the detection of the joy emotion. This finding is in contrast with the findings by Carbon (2020), and is unexpected as the mouth plays an essential role in the expression of joy, and therefore the expectation was that covering the mouth with a mask would impair joy detection. On the other hand, the study by Grahlow et al. (2021, preprint) did not find a significant reduction in the detection of joy when participants were exposed to static material with face masks compared to without face masks. Grahlow et al. (2021, preprint) indicated that this finding could have occurred due to the joy emotion being the only positive and, therefore, most distinct emotion tested in the study. However, the descriptives of the present study show that joy was not detected more easily compared to other emotions. Even more so, joy was only detected better compared to sadness and none of the other emotions.

Effect of face masks and emotion type on wrongful detections of neutral facial expressions

The findings of experiment A also revealed that face masks influence wrongful detections of neutral facial expressions, and result in misinterpretations of sadness and fear as neutral. Therefore, the present study partly confirms the fourth hypothesis that covering the lower half of the face results in emotional states such as joy, sadness, fear, and anger being misinterpreted as neutral. The hypothesis is only partly confirmed as face masks did not substantially affect the wrongful detections of anger and joy as neutral. The findings by Carbon (2020) indicated that many emotional states such as joy, sadness, and anger were misinterpreted as neutral. Despite the fact that the descriptives show almost no misinterpretations of neutral, one could conclude that the actual

emotional state is not always perceived anymore with the presence of face masks. Moreover, the difference between the present study and the study by Carbon (2020) is the use of dynamic instead of static material. Therefore, one could conclude that the dynamic aspect of facial expressions leads to less misinterpretations of joy and anger as neutral. However, no change in facial expression (or barely any other movement) was present in the videos testing for the detection of neutral emotions.

Effect of face masks and word type on word identification

The findings of experiment B reveal that wearing face masks impairs word identification. The interaction showed that for the identification of words that are part of a minimal pair, face masks seem to play an important role. Word identification was not substantially impaired by face masks for words that are not part of a minimal pair. Overall, the present study confirms the fifth hypothesis that covering the lower half of the face results in impaired word identification compared to not covering the lower half of the face. When words are misunderstood, such as the words that are part of a minimal pair, miscommunication can occur. However, in a setting with more context the single words used in the present study might not be as easily misinterpreted. Therefore, further research should be conducted in order to explore the effects of face masks in a conversational, or other high context setting.

When further exploring the interaction between emotion type and face masks, the results of experiment B reveal that for participants exposed to videos including face masks the identification of words that are not part of a minimal pair was substantially higher compared to the identification of words that are part of a minimal pair. For participants exposed to videos without face masks the identification of words that are not part of a minimal pair was also higher compared to the identification of words that are part of a minimal pair, but the type of word had less of an effect. Therefore, the present study confirms the sixth hypothesis that covering the lower half of the face results in impaired word identification for words that are part of a minimal pair to a greater extent compared to words that are not part of a minimal pair. Looking at the means, indeed the identification of words that are part of a minimal pair is influenced to a greater extend compared to the identification of words that are not part of a minimal pair, which is barely affected.

Again, the finding that wearing face masks impairs word identification, especially for words that are part of a minimal pair, was expected since these words are less distinct and can be misinterpreted more easily compared to words that are not part of a minimal pair. No prior research had yet investigated the influence of face masks on the word identification.

Practical implications

In times of the global COVID-19 pandemic, it is crucial to prevent the spread of the virus, and wearing face masks contributes to preventing spread. Therefore, many countries worldwide advise individuals to cover their faces when they leave home or legally implemented mandatory wearing of face masks in public places. Implementing these rules means that many social interactions occur where individuals wear face masks—for example, asking for directions on a train station, conversing with the cashier at the supermarket, or simply greeting someone passing by. In many of these social interactions, face masks could lead to miscommunication. This study is relevant during times of COVID-19 to raise awareness of the influence of face masks on social interactions. The findings of this study show that face masks impair the recognition of emotions, specifically sadness and fear. Therefore, in confusing or emotional situations while wearing a mask, it is advised to ask about others' emotional states, or emphasize one's own emotional state. In other words, individuals should consider carefully expressing their sadness and fear, maybe even verbally, in order for the receiver to understand.

Moreover, based on the findings of the present study, individuals should pay close attention to the articulation of words that are part of a minimal pair. Other options to make sure that a message comes across is speaking louder or asking the receiver if the message was understood. By implementing slight changes like these in our daily conversations, miscommunication can be prevented. In the present study, the sound in both face mask condition was identical. Therefore, future research should investigate the influence of sound variation on communication including face masks.

Another practical implication could be to make use of face masks with mouth visibility. The effect of face masks on emotion detection and word identification is caused by a lack of visibility of the mouth. This could perhaps be solved simply by using see-through face masks.

Lastly, the findings of this study are essential for individuals that have to deliver emotional messages daily, such as nurses, doctors, psychiatrists, or funeral directors. In order to show compassion, often facial expressions of sadness are used in communication of the professions above. Training for people carrying out any of these professions could be helpful to raise awareness and to provide solutions for potential communicative difficulties caused by face masks or other COVID-19 repercussions.

Limitations and future research

The present study was conducted to raise awareness of communicational consequences with regard to face masks. The findings of this study show that face masks indeed influence verbal and nonverbal communication. Nonetheless, this study merely touches upon a limited aspect of communication by only focusing on emotion detection and word identification. This study should be seen as a first step of exploring communicational difficulties in times of a global pandemic. For example, in real-life facial expressions and verbal communication often take place simultaneously. The present study used dynamic material in order to increase the ecological validity. Nonetheless, the present study tested the effect of face masks on emotion detection and word identification separately, due to the importance of the position of the mouth in facial expressions and the fact that speech would influence this position. Therefore, although this study is a step closer to real-life situations as compared to earlier research, future research should incorporate simultaneous speech and emotion expressions to pursue even more ecologically valid results. Furthermore, the face masks used in the video material were counterfeit, and edited on top of the original video (without face mask). Thus, to create more ecologically valid material, the actors could have worn actual face masks. In the present study, the use of counterfeit face masks was incorporated in order to keep the video material as similar as possible between the two face mask conditions. For example, in experiment B, the sound was identical for both face mask conditions. However, in real-life, face masks may dampen sound or people could unconsciously start speaking louder to prevent miscommunication. Therefore, future research should investigate the influence of sound variation on communication including face masks.

Due to the COVID-19 pandemic, the experiment was conducted online with no supervision of the participants. In some cases, participants indicated that a video did not work. Immediate help could have prevented false answers, such as *video does not work*, when the experiment was conducted in a controlled setting. However, this did not happen often, only three participants indicated to have experienced some technical difficulties.

The study might have yielded different findings if the experiment had been conducted in a controlled setting. The participants might have done the current experiment in settings with many distractions or other circumstances that could cause detrimental effects. For example, words that are part of a minimal pair are already difficult to distinguish from another word, therefore (audio) distractions should be kept to a minimum in order to enhance the ability to identify words. However, the fact that this study was not conducted in a controlled setting may in fact be similar to real-life conversations where there is always a possibility for distractions. Therefore, the findings of

this study might actually come closer to real-life communication than if the study had been conducted in a more controlled setting.

Lastly, the findings of the present study show that face masks impaired the detection of all emotions except joy. This finding was in contrast to previous research. Therefore, future research should explore whether the findings of the present study could indicate that face masks perhaps enhance the detection of the joy emotion.

Key take-aways

The COVID-19 pandemic changed the daily routine of many individuals through social distancing, quarantines, hand sanitizing, mandatory face masks, and more. Many of these changes will not disappear anytime soon, and people should adapt to new and unexpected situations. The present study was conducted to explore an effect of the COVID-19 pandemic on communication, namely the effects of the presence of face masks.

Results of this study show that face masks hinder communication in two ways. First of all, the detection of certain emotions (sadness and fear) is impaired by the presence of face masks. Secondly, the identification of words that are part of a minimal pair is impaired by the presence of face masks. The present study focused solely on the effects of face masks on emotion detection and word identification. Nonetheless, the fact that both these communication aspects are indeed influenced by face masks makes one wonder what other influences face masks could potentially have on communication.

Therefore, this study is a first step of exploring communicational difficulties in times of a global pandemic and future research should be conducted to further explore this topic.

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Appendix A

Table 6. *Wordlist consisting of 16 Dutch words that are part of a minimal pair, as used in Experiment B.*

	Dutch [p], [b], [m]	English		Dutch [k], [g], [ŋ]	English
1.	pap	porridge	2.	pak	suit
3.	boom	tree	4.	boog	bow
5.	lap	cloth	6.	lang	long
7.	mat	matt	8.	kat	cat
9.	prijs	price	10.	grijs	grey
11.	eb	ebb	12.	eng	scary
13.	bom	bomb	14.	kom	bowl
15.	rib	rib	16.	ring	ring

Table 7. *Wordlist consisting of 16 Dutch words that are not part of a minimal pair, as used in Experiment B.*

	Dutch	English
1.	papier	paper
2.	koffie	coffee
3.	sigaar	cigar
4.	gordijn	curtain
5.	perfect	perfect
6.	vogel	bird
7.	citroen	lemon
8.	iglo	igloo
9.	ritme	rhythm
10.	toekomst	future
11.	bliksem	lightning
12.	finale	final
13.	kampioen	champion
14.	lelijk	ugly
15.	oorlog	war
16.	tribune	stand