



Negative Stimulus

In subject area: [Computer Science](#)

A negative stimulus refers to threatening or pessimistic information that anxious individuals are particularly attuned to, causing them to focus on and react strongly to such stimuli.

AI generated definition based on: [From Fear to Flow, 2010](#)

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Chapter

Negative affectivity – the emotional dimension

[2010, From Fear to Flow](#)

Jannica Heinström

Anxious perception

Depressed and anxious persons seem almost literally to have a dark cloud over their perceptual processes. Among all the stimuli that surround them and fight for their attention, which ones do they tune in to if not the negative ones? Highly trait-anxious

persons' attention span constantly seems attuned towards threatening information. Their attention processes act like a sensor system that lets stimulus after stimulus pass unnoticed until – aha – a negative one is detected and gets their undivided attention (Gasper and Clore, 2002; Broadbent and Broadbent, 1988). Not surprisingly, but sadly, this distorts their world view to be more pessimistic than it objectively needs to be. No wonder they feel miserable! Their worries get confirmed, their pessimistic outlook fueled and they walk on in a world colored by danger and darkness. As if noticing negativity would not be enough, anxious persons also tend to interpret neutral stimuli in an unnecessarily pessimistic way, often exaggerating and overestimating the likelihood of risk (Zeidner, 2008). How can one then explain this for-them-unfortunate mechanism?

Well, one decisive factor may be an active BIS (behavioral inhibition system) which increases attention and sensitivity towards threat and punishment. The BIS is an inhibiting mechanism designed to protect the organism from misfortunes. It develops through fear, previous disappointments and punishment, and works like an automatic brake function. When an organism [faces](#) a potential threat, the BIS is activated and inhibits [behavior](#) in order to avoid further setbacks. The BIS is particularly alert when the individual is trapped between conflicting impulses of approach or avoidance. While the person is contemplating his/her options but has not yet resolved the response, the BIS is switched on and manifested in rumination or worry. We all have this alert mechanism, but for some it seems particularly wired. They are born with a exceptionally active BIS which creates both state and trait anxiety (Pickering and Corr, 2008).

Overall we are genetically programmed for a stronger and more instinctive reaction towards negative stimuli than towards positive or neutral ones. This is a survival mechanism developed through evolution, just like the automatic reaction to pain which protects us from physical suffering. The processing of negative stimuli is therefore automatic and immediate, and requires little cognitive capacity (Bradley, 1994). Consequently, every one of us

reacts instinctively and intuitively to signals of danger, although some may react more strongly than others. Just as we have developed an instinctive inner alert system to threat on an individual level, humankind has also generated a particular aptitude for danger detection distinctive for some people only. The [evolutionary explanation](#) for trait anxiety lies in this important function of surveillance. These guardians, special protectors of the tribe, would be particularly alert to signals of potential danger and thus warn and shield others (Nettle, 2006). Although our world and along with it new means of protection have since developed, this mechanism still lives today in the [personality trait](#) of [negative affectivity](#).

Alertness to changes in the environment is a basic function critical to survival. Deviant, unexpected or threatening information automatically elicits attention (Lang et al., 2002). Anxious persons seem particularly alert to these signs. They are often restless and vigilant, constantly scanning their environment for potentially threatening messages and reasons to worry (Zeidner, 2008). These mechanisms may be adaptive in the short run, but may go astray for persons who constantly live with exaggerated worry and fear (Rachman, 2004). High negative affectivity thus brings with it a pronounced alertness and sensitivity to signals of danger, even those that are not immediately evident or conspicuous. For calmer people, these cues might go unnoticed. Although trait-anxious people thus recognize what others may have overlooked, they are unfortunately not equally equipped to deal with crises. Highly trait-anxious persons may for instance overestimate the severity of a threat and at the same time underestimate their own ability to cope with it. They are often highly self-critical, prone to unproductive worry and likely to adopt non-adaptive coping forms such as social avoidance, which in turn may further strengthen their negative self-conceptions (Matthews, 2008).

The affect-as-information theory states that feelings are a result of positive or negative interpretations of a situation. According to this approach, sad or unhappy moods signal a problematic situation that needs to be solved. Therefore negative affectivity is

more likely to induce thorough, systematic and detailed [information processing](#) in order to reduce or eliminate the impediment (Forgas et al., 2001; Schwarz, 1990). We need to allocate more cognitive resources for worries and concerns, as they address potential danger and as such are more crucial to our survival. If feelings of anxiety or worry rise to panic mode, our [cognitive processes](#) tighten to allow for detailed analysis of the situation. This may result in selective attention and recall of information. For example, if fleeing people encounter a closed door when trying to escape a hazardous situation, and attempt to push the door open but do not succeed, the anxiety-driven response is to try again with increased effort. In the same situation of finding the closed door but without the danger and panic, it is likely that the alternative solution of pulling the door open would become evident pretty soon. Logic and creative thinking, however, often get blocked by [negative emotions](#). Cognitive processes are focused, but at the price of being limited and trapped. When thoughts are released and widened in positive moods, alternative and creative solutions are more likely to spring forth (Norman, 2002). Happy moods signal a safe and relaxed situation, and consequently there is no particular drive to process information in a careful and detailed manner (Schwarz, 1990). This often leads individuals to consult pre-existing general knowledge structures such as stereotypes or scripts that have helped them in the past (Isbell et al., 2005). Anxiety-driven information processing is thus as a rule thorough, while happy moods make reasoning quick and automatic.

Interestingly, it has been found that persons with low levels of negative affectivity are more likely than their anxious counterparts to run into useful information incidentally (Heinström, 2006c). One reason may be that high levels of anxiety and worry form a tunnel vision for cognitive processes which [focuses attention](#) so exclusively that unexpected stimuli, such as incidentally found useful information, cannot cross the threshold of attention.

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Chapter

Negative affectivity – the emotional dimension

2010, *From Fear to Flow*

Jannica Heinström

Anxious interpretation

[Personality traits](#) may increase the likelihood of experiencing certain emotions and interpreting messages according to them. The negative [mindset](#) common for anxious persons may in this way frame their conception of messages so that they view them in a more gloomy light than is necessary. This in turn feeds additional negativity and further roots the person's negative beliefs.

[Negative affectivity](#) might thus not only influence the goal with information seeking or the way it is executed, but also the interpretation of the retrieved information. The same ambiguous message that a person with low trait anxiety would disregard as harmless, a person with high trait anxiety might view as distressing. This personality-driven cognitive estimate does not depend on the mood or [emotional state](#) the person currently finds him/herself in. The person may feel agitated when he/she encounters the message and makes the unfortunate interpretation, but he/she might just as well be relaxed and serene. Nevertheless, once the message is interpreted as negative, this likely stirs up anxiety and worry and marks the end of the temporary calm. Interpretation style may thus mediate a person's reaction to a certain event, and indirectly increase the person's state anxiety. The stronger the disposition to perceive messages as negative, the stronger is the likelihood of consequent [negative affectivity](#) (MacLeod and Cohen, 1993). This does not imply that the highly anxious person would have a [psychological problem](#) –

it is simply an interpretative bias. The higher sensitivity may also alert to real danger which a calmer person would fail to notice. For the anxious person, however, this creates a world of danger and hardship, which may be a heavy burden to bear. In this way trait anxiety not only directly increases the likelihood of feeling anxious, but also indirectly provokes it through cognitive interpretations. Anxious persons generally both selectively attend to negative stimuli and more easily recall disconcerting memories (Osorio et al., 2003). This notion corresponds to Beck's (1987) theory of emotional vulnerability, which states that anxious persons are more likely to notice information suggesting a risk, interpret ambivalent messages as threats and hold on to negative memories.

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Chapter

Computational Modeling of Cognition–Emotion Interactions: Theoretical and Practical Relevance for Behavioral Healthcare

2017, *Emotions and Affect in Human Factors and Human-Computer Interaction*

Eva Hudlicka

Mechanisms of Therapeutic Action

The phrase “mechanisms of therapeutic action” refers to a set of explanations or hypotheses regarding the means through which particular therapeutic interventions effect change in, or ultimately cure, a specific disorder. The term “mechanism” is used rather loosely in the psychotherapeutic community, depending on

the theoretical orientation of the associated approach. In some cases, it refers to empirically validated and theoretically grounded hypotheses regarding the nature of the processes that effect change, specified at a level of detail that would support computational modeling; for example, [systematic desensitization](#) treatments of various anxiety disorders, including phobias and [PTSD](#), which involve a variety of low-level conditioning and learning mechanisms. In other cases, the term refers to very high-level descriptions of change processes, which are not empirically grounded and whose theoretical foundations are not framed in terms of falsifiable hypotheses, as is the case with most [psychoanalytic theories](#). In yet other cases, promising ideas are introduced which suggest interesting directions but do not provide sufficient level of detail to support modeling, for example, recent suggestions that a heightened level of arousal is required to transform cognitive structures from maladaptive to adaptive beliefs and interpretations, via processes analogous to annealing in physics.

Increasingly, however, there is emphasis on specifying mechanisms of therapeutic action in terms of the cognitive and affective processes, and associated structures, that lend themselves to symbolic modeling. The specific structures and processes proposed depend on the theoretical orientation of the associated approach. Given the emphasis on fundamental [cognitive processes](#) (e.g., attention, memory) and low-level learning mechanisms (classical and operant conditioning) in [cognitive therapies](#) (CT) and cognitive-behavioral therapies (CBT), it is not surprising that [CT](#) and CBT provide descriptions of mechanisms that are computation-friendly, and lend themselves to symbolic computational modeling. Of particular interest is the recent research on the role of cognitive biases in affective disorders. Specifically, threat biases in attentional and interpretive processing appear to mediate anxiety disorders. These biases operate on low-level processes and outside of conscious awareness (Mathews and MacLeod, 2005), inducing what MacLeod and Mathews refer to as “maladaptive patterns of selective information processing” (MacLeod and Mathews, 2012, p.

197). Empirical studies have confirmed that individuals who suffer from anxiety disorders, as well as trait-anxious individuals, selectively focus on negative information (Bar-Haim et al., 2007) and experiments involving interventions targeted at directly reducing these biases demonstrated reductions in symptoms; for example, reducing attentional bias toward negative stimuli resulted in reduction of intrusive negative thoughts contributing to anxiety and depression (Hayes et al., 2010). Therapeutic approaches based on these mechanisms have been developed, the [Cognitive Bias modification](#) (CBM) approaches, and will be discussed in Sections “Modeling the Mechanisms of Therapeutic Action” and “Treatment.”

Another example of recent focus on mechanisms is a [process model of emotion regulation](#) proposed by Gross (Gross, 1998), which emphasizes an information-processing framework and identifies five types of processes that contribute to emotion regulation. Gross’ model includes processes controlling situation selection, situation modification, attention deployment, cognitive change, and [response modulation](#). Although not addressing the mechanisms of actions of specific therapeutic approaches, the model provides a framework for integrating multiple processes involved in emotion regulation, thereby providing a basis for developing mechanism-based models of emotion regulation that span multiple therapeutic approaches, and involving multiple modalities of emotion.

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Chapter

Emotional Modulation of Perspective Taking

2016, Emotions, Technology, and Behaviors

Overview of the Study and Research Question

This study explored whether one's own emotions might influence the ability to address others' perspectives during argumentation. The study aim was to assess the extent to which emotional stimulations differing in valence (i.e., positive, negative, or neutral) influenced the processing of a counterpart's perspective. The study combined a vignette methodology for assessing perspective taking developed by Kuhn and Udell (2007) with an *affective priming* paradigm, which has proven to be a robust method of emotional stimulation (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). In affective priming studies, positive or negative stimuli (i.e., primes) such as words or pictures are presented rapidly ($\cong 50$ ms), followed by a behavioral task. The response to the priming stimuli is thought to influence the response to the subsequent stimuli. The study aimed to answer the following research question:

How do one's own emotions influence the ability to address a counterpart's perspective during argumentation?

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Chapter

Neural Mechanisms of Emotions and Affect

2017, *Emotions and Affect in Human Factors and Human-Computer Interaction*

Emotional Appraisal and Recognition Processing Beyond the Amygdala

Areas of the cortex also play a role in the recognition of emotions. Recognizing emotions, especially in other people, is an important aspect of social [behavior](#). Without the ability to recognize that another human can feel pain and joy similar to oneself, a person would have a hard time fitting in with society. Many experiments examining the ability to recognize emotions, including experiments described here, use facial expressions as stimuli to determine whether someone can recognize an emotion. The emotions communicated by [faces](#) are communicated by the changeable aspects of the [face](#), such as the eyes or mouth (Bassili, 1979). For instance, fearful faces can be characterized by a widening of the eyes, flaring nostrils, and gaping mouth (Susskind et al., 2008). Research suggests that the ability to recognize a facial identity and the ability to recognize the changeable aspects of a face involve separate neural systems. Face identification is related to the lateral [fusiform gyrus](#) whereas recognition of facial expression is related to the [superior temporal sulcus](#) (STS; Haxby et al., 2000; Hoffman and Haxby, 2000). A study using MEG found that responses in the STS occurred along with responses in the [amygdala](#) when judging the expression of an emotional face compared to a neutral face (Streit et al., 1999). Further evidence that a network involving the STS and amygdala is involved in the recognition of emotion in faces comes from fMRI and [lesion studies](#) (Campbell et al., 1990; Lahnakoski et al., 2012).

The STS has connections to many different areas of the brain involved in different dimensions of [social cognition](#). Of particular interest to this chapter are the connections from the STS to the amygdala. Researchers presented healthy subjects with videos that depicted different social features (faces, bodies, biological motion, goal-oriented action, emotion, social interaction, pain, and speech) while they underwent fMRI scans. The authors found

that the anterior STS and the amygdala formed a network sensitive to speech and the communication of emotions through facial expressions and/or body language (Lahnakoski et al., 2012). In rhesus monkeys, it has also been found that ablation of the STS leads to deficits in the ability to discriminate the direction of eye gaze, a result that is also found in humans with [prosopagnosia](#) (i.e., the inability to recognize faces; Campbell et al., 1990).

Damage to the [somatosensory cortex](#) can also lead to an inability to recognize emotion in others even when the amygdala is intact. One group of researchers examined 108 patients with [brain damage](#) to assess possible regions of cortex associated with deficits in the ability to recognize emotion. In two experiments, the brain-damaged patients along with controls were shown 6 blocks of the same 36 emotional faces (6 faces each of happiness, surprise, fear, anger, disgust, and sadness) and asked to rate the intensity of the emotion in one experiment and match the expression with the written name of the expression in the second experiment. In a third experiment, participants sorted a subset of 18 facial expressions (3 of each emotion) into emotion categories that were similar. The researchers divided the group in half based on intensity scores in experiment one and found that those in the bottom half (more impaired) had localized damage to the somatosensory cortex. When the groups were further divided into the top and bottom 25% of intensity rankings, localized somatosensory damage was found again. Examination of performance as a function of lesion location in the second and third experiments further revealed the necessity for intact somatosensory cortex for normal recognition of all emotions. A post hoc analysis of medical records found a correlation between impairment in emotion recognition and [somatic](#) sensation (Adolphs et al., 2000). Based on these results and results from other studies of STS function, the authors concluded that visual and somatosensory representations of emotions and the white matter connecting regions of the brain that support the representation of this information allow one to recognize the mental state of another by simulating the observed state in oneself (Adolphs et al., 1994; Adolphs et al., 2000; Adolphs

et al., 2005; Campbell et al., 1990; Haxby et al., 2000; Lahnakoski et al., 2012).

Although the amygdala has been extensively studied in the context of negative emotions, it also plays an important role in positive emotions and can be thought of as a general salience detector (Sander et al., 2003). The brain appears to also have a region that is primarily associated with reward processing—the [nucleus accumbens](#) of the [ventral striatum](#) (Knutson et al., 2001a; Kravitz et al., 2012; Olds and Milner, 1954). Early studies on reward and pleasure in the brain used a technique of electrical self-stimulation in rats (Olds, 1958; Olds and Milner, 1954). This technique involves placing an electrode into the brain of a rat. The wires leading into the electrode hang from the ceiling of a Skinner box to allow free movement by the animal. The Skinner box, a controlled environment used in animal behavior experiments, contains a lever that controls the electricity sent to the subject's brain and the subject is free to push the lever. Olds and Milner (1954) used this technique, implanting electrodes into different brain regions and then correlating bar presses and extinction of bar presses to electrode placement. The results indicated that electrode implantation in the septal region, beneath the [corpus callosum](#), resulted in the highest amount of bar presses. Furthermore, the results of self-stimulation were comparable with those of studies using typical reinforcers, such as food. A modern take on this study has used [optogenetic techniques](#) to stimulate [dopaminergic activity](#) in the [striatum](#) of rats (Kravitz et al., 2012). In this study, a rat was placed in a Skinner box with two levers, one of which did nothing and the other turned on a laser that, depending on experimental condition, would either stimulate excitatory D1 receptors or inhibitory D2 receptors. The results indicate that activation of D1 receptors increases the probability that the rat will respond again, whereas D2 activation results in the animal moving away from the lever and decreased probability of response (Kravitz et al., 2012). Thus, the striatum and dopamine may be involved in the detection of both rewarding and punishing stimuli.

An increase in [BOLD](#) signal has been found in the nucleus accumbens/ventral striatum in anticipation of increased reward using fMRI (Knutson et al., 2001a). In a seminal study, researchers presented participants with a task, during fMRI scans, in which a cue either signaled a small or larger monetary reward (gain \$0.20, \$1, \$5), a small or larger monetary loss (lose \$0.20, \$1, \$5), or no monetary loss or gain. During conditions in which the cue stimulus signaled loss or gain, the subjects responded to a target appearing on screen for 160–260 ms. If they pressed the button while the square was on screen they either avoided the loss or received more money. The results of fMRI analysis indicated greater BOLD signals in the nucleus accumbens during anticipation of reward compared to no reward. An additional fMRI study revealed that the ventral striatum is related to predicted monetary reward versus nonreward outcomes (Knutson et al., 2001b). Similar fMRI activation in the ventral striatum has been observed in anticipation of other positive/rewarding stimuli such as erotic movie clips (Greenberg et al., 2015). Collectively, these findings provide evidence that the nucleus accumbens is active during the anticipation of reward, meaning it is involved in the appraisal and recognition of rewarding stimuli.

Appraisal of emotional stimuli and accurate recognition of the emotion are important aspects of survival as well as the more mundane aspects of daily life. In the case of S.M., damage to the amygdala resulted in an inability to recognize fear in faces, show normal fear responses, and a tendency to be more trustworthy and friendly than the normal person (Adolphs et al., 1998; Bechara et al., 1995). Thus, there are very real consequences as a result of damage to the amygdala. In addition to the amygdala, different cortical regions are also necessary for appraising emotional stimuli and recognizing emotions. The somatosensory cortex appears to be necessary for recognizing other's emotional expressions by simulating the feelings of others in ourselves (Adolphs et al., 2000). The STS is connected to the amygdala, which is important for processing facial expression and body language (Haxby et al., 2000). The nucleus accumbens also plays a role in

the evaluation of emotional stimuli as it is involved in predicting rewarding outcomes (Knutson et al., 2001b). The amygdala is an important structure in the appraisal of environmental stimuli for emotional significance. However, other structures are also involved. For instance, the cortically generated N1 ERP component can be modulated by both positive and negative stimuli (Weinberg and Hajcak, 2010). Thus, there are multiple and distributed regions in the brain for detecting and appraising the significance of emotional input and we have only introduced a few of these structures here.

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Review article

Reinforcement learning for crop management support: Review, prospects and challenges

2022, Computers and Electronics in Agriculture

Romain Gautron, ... Régis Sabbadin

Glossary	
action	How the environment dynamics are controlled by the agent.
action space	The set of possible actions.
agent	The entity that acts on the environment in order to optimize the objective function.
deep neural network	Neural network with several layers. In reinforcement learning, this number of layers is limited (from a few to a dozen layers)

whereas in general machine learning, there may be hundreds and even thousands of layers.

environment	The object with which the agent interacts.
episode	A single sequence of interactions of the agent with the environment, from a given initial state.
exploration-exploitation dilemma	The situation in which an agent has the choice between performing an action with consequences which are known (exploitation) and an action with consequences which are unknown (exploration).
horizon	Maximum number of time steps of an episode.
in silico	A virtual experience.
internet of things (IoT)	Networks of uniquely identified physical devices which can autonomously communicate between themselves or with humans, and process data.
Markov decision process	Mathematical formalization of the environment in a reinforcement learning problem, see Fig. 5.
neural network	A neural network is made up of a set of layers of simple computation units, called neurons. Each neuron receives data as input and outputs one or more labels (usually either symbolic, or numeric). Mathematically speaking, a neural network is a function.
objective function	The function that the agent optimizes by controlling the environment.
observation	In a Markov decision process, a snapshot of the environments state. In the general case, there is no assumption that an optimal action may be determined using an observation.

overfitting	A machine learning model that has been trained and performs well in training situations but performs poorly in unseen situations.
policy	A function that indicates how the agent acts depending on the environments state.
quality function	The expected value of the objective function when the environment is in a given state and the agent first performs a given action and then follows a given policy.
return	A positive or negative stimulus (usually a real value) provided by the environment to the agent which indicates if the past actions have been beneficial to the agent with regards to its objective.
sample complexity	Number of samples required to solve a problem. The higher the sample complexity, the harder the problem.
state	A set of descriptors of the environment that is sufficient to decide on an optimal action.
state space	The set of possible states.
stationary	A random process in which distributions do not change over time.
value function	The expected value of the objective function when the environment is in a given state and the agent follows a given policy.

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Review article

Speech emotion recognition approaches: A systematic review

2023, *Speech Communication*

Ahlam Hashem, ... Manal Alghamdi

5 Speech processing

After defining the database, to build an emotion recognition system from the audio, there is a need to preprocess the available sample. Preprocessing is a significant step that refers to procedures that must be performed on speech signal samples (Nema and Abdul-Kareem, 2018). [SER](#) systems are more complex processes in which [recognition accuracy](#) depends on several stages. As mentioned in the earlier section, the data utilized in the entry affects the results extracted. Therefore, in the first step, and before extracting features from the audio clips, the sample signals must be preprocessed to improve the existing data as much as possible to focus on salient features and to facilitate subsequent operations such as removing silent intervals and pre-emphasis, where some studies utilized the pre-emphasis step, which is used to boost the signal's high frequencies by using a pre-emphasis filter (Zayene et al., 2020). These processes can be done for feature extraction. Others can be for normalizing the features where all utterances must undergo some energy normalization due to variations in recording environments, or some specific characteristics of the speakers are removed, such as the gender and age of the subjects (Nema and Abdul-Kareem, 2018). Fig. 5 illustrates the five processing steps discussed.



Fig. 5. Processing techniques of signal for speech emotion recognition.

5.1 Signal framing

Framing is also known as speech segmentation. Framing divides speech samples between 20 and 40 ms, collected from [analog to digital conversion](#) (ADC) into small frames. One problem on the SER dataset has varying sample lengths (Li et al., 2020). Therefore, the audio wave signal is segmented into fixed lengths sections. The segmentation approximates the [local features](#) from the close to a stationary state. As known, speech signals are non-stationary; nevertheless, they remain constant for a short interval (Ozseven, 2018). Therefore, these frames should be related to each other by overlapping where most studies overlapped frames signals between 30% and 50%. Fig. 6 illustrates the segmentation of the signals with an overlapping. The benefit of framing the signals is to obtain them in a fixed length, which is suitable for the classifier while keeping the emotional knowledge in speech. Some feature extraction techniques like the use of Discrete [Fourier Transform](#) (DFT), where continuous speech signals may control the use of processing (Heinzel et al., 2002).

5.2 Windowing

After completing the framing phase, the second phase is to apply the [window function](#) to the frames. To enhance a sampled signal's [spectral properties](#), use smoothing windows where it can be used to reduce the discontinuities of truncated waveforms, hence lowering spectral leakage while doing Fourier or spectral analysis on finite-length data (Beigi, 2011). The amplitude of the discontinuity determines how much spectral leakage occurs. Spectral leakage grows as the discontinuity gets more expansive, and vice versa. Smoothing windows function as narrowband lowpass filters by reducing the magnitude of discontinuities at each period's boundaries (Heinzel et al., 2002). When [windowing](#) a signal, the time record is multiplied by a smoothing window of

limited length, whose amplitude gradually decreases to zero at the window's edges (Hamid, 2018). When windowing a signal, the time record is multiplied by a smoothing window of limited length, whose amplitude gradually decreases to zero at the window's edges. The number of samples determines the smoothing window's length or time interval. Convolution in the frequency domain is the same as multiplication in the time domain. As a result, the windowed signal's spectrum is a convolution of the original signal's spectrum and the smoothing window's spectrum. In addition to altering the spectrum, windowing modifies the time domain form of the signal (Prabhu, 2014). A [Hamming window](#) is commonly utilized, as shown in Eq. (1), where the window size is M for the frame $w(n)$.

$$w(n) = 0.54 - 0.46 \cos\left(\frac{2\pi n}{M-1}\right) \quad (1)$$



Fig. 6. The segmentation of the signal with an overlapping.

5.2.1 Time windows

SER is the task of automatically identifying emotions from audio speech signals, Where the time window refers to the duration of speech segments used for feature extraction and emotion classification. It involves dividing the continuous speech signal into smaller segments to analyze emotional expressions' acoustic properties and temporal patterns. The time window in SER is essential because emotions are dynamic and evolve. Also, the effectiveness of features depends upon the duration of the time window chosen. Different emotional cues may manifest at various temporal scales, and capturing these cues within appropriate time windows is crucial for accurate emotion recognition (Jalal et al., 2020). The time window for which emotion recognition is relevant in SER can vary depending on the type of feature being used.

Research has shown that emotions can be recognized within relatively short time windows, typically ranging from a few hundred milliseconds to a few seconds. For example, studies have shown that [vocal expressions of emotions](#) can be recognized within 1–3 s (Scherer, 1995), while acoustic features such as pitch and intensity can be analyzed over a shorter time (Eyben et al., 2010). Short windows of audio data are often used to form a feature vector for classifying the whole utterance. These feature vectors can be based on various acoustic features, such as pitch, loudness, [spectral energy distribution](#), and [cepstral coefficients](#) (Boateng et al., 2022). There are many techniques to combine information from multiple time frames that can be used for SER to determine the utterance-level emotion for each [input utterance](#), including temporal feature integration, which involves combining features extracted from multiple time windows to capture temporal dynamics in the data (Ntalampiras and Fakotakis, 2011), majority voting which involves aggregating the predictions of [multiple classifiers](#) to make a final prediction (Kurpukdee et al., 2017), and deep [learning approaches](#) which involve [training neural networks](#) to automatically learn features from raw data (Raj et al., 2023; Jiang et al., 2019). The tradeoff between time and frequency resolution in SER is influenced by the size of the time window used for analysis, with more oversized windows providing better time resolution but sacrificing frequency resolution and vice versa for smaller windows (Yang et al., 2019). Several studies have explored the optimal time window for different acoustic features. Paliwal et al. (2010) study concludes that the optimal window duration for speech analysis is between 15–35 ms, which is especially suitable for speech applications relying on the short-time magnitude spectrum (Puterka and Kacur, 2018). The study investigated the impact of speech signal duration on emotion recognition, testing segments of varying lengths. Longer speech segments demonstrated higher accuracy, with a significant difference of over 17% between the shortest and longest sequences. Puterka et al. (2019) aimed to determine whether it is better to use shorter or longer windows that identify the optimal parameters for SER classification, explicitly

investigating the appropriate time and frequency resolution of [spectrograms](#). Based on the obtained results, it can be inferred that utilizing a window length of 10 ms with a 50% overlap of neighboring frames is sufficient to achieve accurate classification into seven emotional classes. It concludes that the optimal time window for SER depends on the context and the type of emotion recognized. Shorter time windows may be more helpful in capturing dynamic changes in emotion, while longer time windows may be more beneficial for capturing overall trends in emotion. In other words, the time window for which emotion recognition is relevant can vary depending on the specific application and context. In some cases, emotion recognition may be relevant in real-time, where emotions must be detected and recognized as they occur, such as in customer service interactions, [virtual reality experiences](#), or driver [safety systems](#) (Requardt et al., 2020). In other scenarios, emotion recognition may be relevant for analyzing emotions over extended periods, such as in healthcare settings for monitoring and diagnosing patients' [emotional states](#) or in market research to understand consumer sentiment and preferences over time (Han et al., 2020; Madanian et al., 2022). The relevant time window for emotion recognition will depend on the specific goals and requirements of the application. Some applications may require immediate and real-time recognition, while others may focus on analyzing emotions over extended periods to gain insights and make informed decisions.

Table 6 compares different time window sizes used in SER studies along with the best performance results achieved. Most of the papers explain the window size as a pre-process step with no justification; however, when the time window increases between 60–265 MS, its possible that the study wants to focus more on [frequency information](#) in each frame since the frequency resolution is higher, and when the time window is less between 10–40 MS it is possibly that the study wants to focus more about temporal information in each frame since the temporal resolution is higher. Most studies used a time window size of 25 ms, with different features, models, and datasets such as FAU AIBO,

IEMOCAP, EMO-DB, EMOVO, and SAVEE. The reason for using this size goes to extract short-term information. Also, some studies assume that 25 ms contains sufficient emotional information (Han et al., 2014). The time window size of 20 MS was chosen in Ancilin and Milton (2021) because a longer frame duration can lead to changes in signal characteristics within the frame. The method was evaluated using a 10-fold cross-validation, resulting in an accuracy of 81.50%. After the experiment, Gilke et al. (2012) found that the highest mean classification score gave with 23.22 MS. It is still an open problem to determine the appropriate analysis window for emotion recognition. Fortunately, a speech segment over 250 MS has been shown to contain sufficient emotional information (Kim and Provost, 2013). These varying results indicate that the choice of window time size is crucial but not the only factor affecting accuracy but also the [data type](#), model, and metrics used.

Table 6. Comparison between different time window sizes used in SER literature. (MS: Millisecond, WA: Weighted accuracy, UA: Unweighted accuracy, UAR: Unweighted Average Recall).

Time window size	References	Best performance
20 MS	Ancilin and Milton (2021)	Accuracy: 81.50%
23.22 MS	Gilke et al. (2012)	WA: 79.55%
25 MS	Zayene et al. (2020), Zhao et al. (2021b), Yi and Mak (2020), Guo et al. (2018), Alam et al. (2013), Han et al. (2014), Bertero and Fung (2017), Lee et al. (2019), Hsu et al. (2021), Li et al. (2021a), Zhang et al. (2021) and Liu et al. (2022).	WA:73.1% UA:66.3% (Zhao et al., 2021b) WA:84.49% UAR:83.31% (Yi and Mak, 2020) Precision:93.30%, Recall:91.97%, F1:92.50% (Guo et al., 2018)

Time window size	References	Best performance
30 MS	Li et al. (2021c)	UW: 56% WA: 61%
40 MS	Dai et al. (2019) and Zou et al. (2022)	UW:60.98% WA:58.93%, WA:71.64% UA:72.70%
64 MS	Aftab et al. (2022)	UW: 94.15%, WA: 94.21%, F1: 94.16%
65 MS	Fan et al. (2021)	WA: 62.4%, UA: 42.9%

From another perspective, considering the extent of acoustic information necessary for a listener to recognize vocal emotional expressions has been a subject of inquiry in the research. In an early investigation, Pollack et al. (1960) conducted a study on vocal emotion recognition, where they observed that recognition accuracy improved with longer gate lengths. They found that recognition of 8 distinct “modes of expression” exceeded chance levels for utterances as short as 60 ms. It is worth noting that while fear and happiness were among the included emotions, most of the “modes” were non-emotional, such as statements, questions, and confidential communication. However, their study needed more specific data reporting for individual emotions, and the limited methodological details provided hindered a comprehensive evaluation of their findings. Audibert et al. (2007) explored the perception of various [affective states](#) using six gates to divide single-word utterances. In the previous vocal gating studies reviewed (Cornew et al., 2010; Lacheret et al., 2007; Jiang et al., 2015; Pell and Kotz, 2011; Rigoulot et al., 2013) [negative emotions](#), such as anger, fear, and sadness, have consistently demonstrated faster recognition compared to happiness. Notably, most of these studies have predominantly focused on happiness as the only [positive emotion](#) investigated, except for Audibert et al. (2007). More recently, Nordström and Laukka (2019) study significantly broadens the scope of previous gating investigations by incorporating an extensive repertoire of vocal expressions such as anger, fear, happiness, interest, sadness...etc. They explore

the rapid recognition of emotions from speech and music by humans. The study aimed to explore the time course of emotion recognition in speech and music. Emotions are an essential aspect of human communication, and understanding how they are perceived and recognized is crucial for various fields, including psychology, linguistics, and communication sciences. The researchers employed a gating paradigm, a method commonly used in studies of emotion recognition, to estimate the amount of acoustic information required for accurate emotion recognition. This paradigm involves presenting stimuli in sequential segments or “gates”, starting from very brief excerpts and gradually increasing the duration of the stimuli. By doing so, they could pinpoint the shortest gate duration at which participants could accurately recognize each specific emotion. Additionally, the study analyzed the Emotional Identification Points (EIPs), representing the time when recognition rates stabilize for each emotion. The study included a diverse range of emotions in speech and music to ensure a comprehensive investigation of emotion recognition. The emotional expressions encompassed a variety of valence (positive and negative) and arousal levels, allowing for an exploration of how these factors influenced recognition speed. The findings revealed exciting patterns in emotion recognition. While some emotions were quickly recognized from brief stimuli, others required longer durations for accurate identification. Negative emotions, such as anger, fear, and sadness, appeared to be recognized faster than [positive emotions](#), except for happiness. This aligns with previous research indicating that negative stimuli tend to draw more attention due to their potential threat value. Moreover, the study shed light on the acoustic features that enable rapid emotion recognition from speech and music. It suggested that low-level physical characteristics, such as F0 level, voice intensity, and voice quality, played a crucial role in discriminating between emotions. These features were rapidly expressed and detected within a few glottal cycles, emphasizing the efficiency and speed of emotional communication through speech prosody and music. However, the results also highlighted an intriguing exception: the emotion of relief. Relief recognition

required stimulus durations significantly longer than other emotions, implying that it might rely on cues that develop over time or emerge toward the end of an utterance. This finding opens up new avenues for investigating the temporal dynamics of specific acoustic cues associated with relief and exploring how they contribute to emotion recognition. The study by Nordström and Laukka (2019) provided valuable insights into the time course of emotion recognition in speech and music. Using the gating paradigm allowed for a detailed analysis of how quickly various emotions can be identified from acoustic information. The findings suggest that acoustic cues play a vital role in emotion communication and that different emotions may exhibit distinct recognition patterns. Further research in this domain can contribute to a [deeper understanding](#) of human emotional processing and its implications in various fields, such as emotion recognition technology, human–computer interaction, and [affective computing](#).

5.3 Voice activity detection

Generally, an utterance consists of three elements: voiced, unvoiced, and silent. The voiced utterance is produced by the [vocal folds](#) vibrating, which periodically excites the [vocal tract](#) during [phoneme](#) pronunciation. The phonemes are perceptually different units of sound that differentiate between words. Unvoiced speech results from air flowing through a constriction in the vocal tract, creating noises that are brief and turbulent and are caused by periodic excitations of the vocal tract. Recognizing and extracting spoken communication is possible because of its periodic character. Endpoint detection, speech detection, or vocal activity detection are terms used to identify voiced speech among other unvoiced speech and silence (Lokhande et al., 2012). The voice Activity Detection algorithm's performance impacts the system's accuracy. Suppose speech has many noisy and silent frames, which raises computing complexity. Therefore, removing silence frames with less energy depending on a certain threshold makes modeling speech easier and reduces the complexity (Yiming and Rui, 2015). The auto-correlation method, short-time energy, and zero crossing rate are the most often utilized

techniques for vocal activity detection (Lokhande et al., 2012). Nevertheless, some studies attempt to use unvoiced speech and silence features to enhance the result of SER, which is covered in Section 8.

5.4 Normalization

Normalization can be done on the features level or corpus level. The idea of [feature normalization](#) is to modify the volume sound into a standard level by computing the maximum value of the signal and then dividing the entire [signal sequence](#) by this maximum (Nema and Abdul-Kareem, 2018). The benefit of this step is that it enhances the [generalization ability](#) without losing the discriminative strength of the features by reducing the recording and speaker variability (Sun and Wen, 2015). The best-known normalization is Z-normalization (Auckenthaler et al., 2000), which mathematically can be represented in Eq. (2), where μ is the mean, and α is the [stander](#) deviation of the speech signal.

$$Z = \frac{x - \mu}{\alpha} \quad (2)$$

5.5 Noise reduction

The amount of noise in the signals depends on the data type, where the noise in the speech signals is inevitable. However, it may exist more in the natural speech data since it is taken from real life in different environments. This noise interferes with the sound waves, negatively impacting the recognition process and resulting in poor performance accuracy, which happens because the [audio signals](#) may be corrupted by the different types of noise (Thu et al., 2019). Various techniques have been used to reduce this noise, also called unwanted signals. [Denoising](#) techniques are applied to reduce unwanted signals from audio. Such techniques used are minimum mean square error (MMSE) and log-spectral amplitude MMSE (LogMMSE), which are considered the most successfully used techniques for denoising, where it improves the results (Pohjalainen et al., 2016).

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Emotional Modulation of Perspective Taking

2016, *Emotions, Technology, and Behaviors*

Ulises Xolocotzin, ... Sibel Erduran

Exploring How Emotions Might Influence Perspective Taking During Argumentation

Overview of the Study and Research Question

This study explored whether one's own emotions might influence the ability to address others' perspectives during argumentation.

The study aim was to assess the extent to which emotional stimulations differing in valence (i.e., positive, negative, or neutral) influenced the processing of a counterpart's perspective.

The study combined a vignette methodology for assessing perspective taking developed by Kuhn and Udell (2007) with an *affective priming* paradigm, which has proven to be a robust method of emotional stimulation (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). In affective priming studies, positive or negative stimuli (i.e., primes) such as words or pictures are presented rapidly ($\cong 50$ ms), followed by a behavioral task. The response to the priming stimuli is thought to influence the response to the subsequent stimuli. The study aimed to answer the following research question:

How do one's own emotions influence the ability to address a counterpart's perspective during argumentation?

Methods

Participants and Design

Participants were 30 native English speakers from a range of socioeconomic and academic backgrounds, between 25 and 35 years old, 60% women. All participants were recruited through public advertisement in a midsize city in southwest England and received money as inconvenience allowance.

The experimental design was within participants with three conditions of affective stimulation: neutral, negative, and positive. In addition, to control for the effects of individual differences, all participants answered the [Interpersonal Reactivity Index](#) (IRI), which is a widely used measure of individual differences in empathic orientation (Davis, 1983). The 28-item [IRI](#) contains four subscales (seven Likert items each), including perspective taking, empathic concern, [personal distress](#), and fantasy.

Apparatus and Stimuli

The stimuli were presented over a black background with a laptop computer in a 15-in. screen using Psychopy (Peirce, 2007). Affective primes were pictures from the International Affective Picture System (IAPS). A set of pictures was selected including images with neutral, positive, and negative content. None of the selected pictures included faces to avoid social reactions effects (e.g., attractiveness). To ensure that the selected stimuli varied only in terms of their valence, all pictures were selected to have a moderate arousing effect as indicated by the IAPS manual (Lang, Bradley, & Cuthbert, 2008).

After each priming stimuli, individuals responded to an argumentation vignette similar to the ones developed by Kuhn and Udell (2007). The vignettes included arguments defending one's own position and arguments addressing other's position. For example:

You are told you should eat crisps instead of ice cream. You prefer ice cream. What is the best argument for you to make?

- Ice cream is sweet.
- Crisps make you thirsty.

Note that both argument choices are aimed to support one's own position, but one of them is directed to strengthen an individual's own argument (top option in the preceding example), whereas the other argument addresses the counterpart's argument (bottom option). Thus, choosing the position that addresses a counterpart's point of view might indicate engagement with effortful perspective taking. The content of the vignettes included a range of everyday situations likely to be common for most participants.

Topics included choices on food, social activities, sports, and so on. The final vignettes used in the study were selected and refined after a pilot study that indicated that neither choice would be more likely to be chosen, regardless of being directed to support one's own perspective or to address a counterpart's perspective.

The vignettes were presented at the top center of the screen simultaneously with the argument choices positioned at the bottom left and right.

Procedure

Participants were tested in a quiet room. Before a testing session, participants were told that they would be asked to give their opinion about a series of common situations. The experiment started with an introductory screen explaining to the participant that he or she was going to see a picture followed by a short story with two options, and that they should ignore the first picture and concentrate on the story. The screen also instructed participants to imagine themselves in the situation described in the story and select the best argument to defend their position. The initial screen was followed by three practice trials.

Figure 1.1 shows the sequence of events on each experimental trial. A trial started with a blank screen for 3000 ms followed by a central fixation point displayed for 2000 ms. Next the prime picture (negative, positive, or neutral) was displayed for 50 ms followed by a structural mask displayed for 50 ms, to make a stimulus-onset asynchrony (SOA) of 100 ms. Finally, the vignette and the argument choices were presented until the participant pressed one of the designated buttons to make a choice. Whether the argument choices appeared in the left side or the right side was counterbalanced across trials. Participants' task was to click on the designated keyboard key at the right or left to indicate their choice of argument. Responses of both latency and argument choice were collected. Each participant performed 30 trials, 10 for each condition of emotional stimulation, presented at random. Valence of the affective primes (positive, negative, or neutral) presented before each of the 30 vignettes was counterbalanced across participants using a Latin square design. After the

experiment, participants answered the IRI, then they were debriefed and the session finished.



Figure 1.1. Sequence of events on a trial. *Notes:* SOA = stimulus onset asynchrony.

Results

Data screening: Following Wentura and Degner (2010), responses with a latency falling more than three interquartile ranges above the third quartile of the distribution might be considered too slow to be indicative of priming effects. Responses of this kind represented 2.6% of the collected data and were discarded from further analysis. In addition, 25% of the responses of one participant were found to meet this criterion, and therefore, data from this participant was also removed from further analysis. Another three participants failed to address a counterpart's perspective at least once in one condition; therefore their data was not included in the [multivariate analyses](#) presented later.

Argument choices: First we tested whether the preference for arguments strengthening one's own position over arguments addressing a counterpart's perspective was significantly above chance for each of the valence conditions. One-sample *t*-tests were conducted to compare each condition against a theoretical 50% chance baseline. All conditions were above chance (all *ts* > 2.2, all *ps* < 0.03), suggesting that participants did not answer the task mindlessly (i.e., randomly) and, instead, showed a systematic tendency to focus on their own perspective. Further analysis tested differences in the selection of arguments addressing a counterpart's perspective. A repeated measures [analysis of variance](#) (ANOVA) with valence (positive/negative/neutral) as a

within-subjects factor was applied to the proportion of responses addressing a counterpart's perspective. The results indicated no significant effects of valence [$F(2, 24) = 0.418$, ns], as is illustrated in Figure 1.2a.



Figure 1.2. Proportion of responses addressing a counterpart's perspective (a) and response latencies (b). Error bars denote ± 1 SE.

Latency: Reaction times were analyzed with a repeated-measures ANOVA with valence (positive/negative/neutral) and perspective (own/other) as within-participants factors. The results showed no main effects of perspective [$F(2, 25) = 1.64$, ns] or the valence $\times$ perspective interaction [$F(2, 24) = 0.84$, ns]. However, there was a main effect of valence [$F(2, 24) = 5.23$, $p < 0.05$]. Bonferroni post hoc tests revealed no significant differences between the neutral and the negative valence conditions, but confirmed significantly larger latencies in the positive condition in comparison to both the neutral and negative conditions ($ps < 0.05$). These results are illustrated in Figure 1.2b.

Interpersonal Reactivity Index (IRI): None of the IRI scales were significantly correlated either with the overall proportion of responses addressing a counterpart's perspective or individuals' reaction times (RTs) (all $rs < 0.24$ and > -0.36 , all $ps > 0.05$).

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Chapter

Neural Mechanisms of Emotions and Affect

2017, Emotions and Affect in Human Factors and Human-Computer Interaction

Jacob Aday, ... Joshua M. Carlson

Emotional appraisal and recognition

Early theories on the neural mechanisms of emotion focused on structures believed to be phylogenetically (evolutionarily) older as emotion is also believed to be phylogenetically older. Many of these structures were subcortical (i.e., beneath the neocortex). Two early models of emotional brain systems were the “Papez circuit” (Papez, 1937) and “limbic system” (MacLean, 1949, 1952). The [limbic system](#) consists of the cortex adjacent to the [olfactory tract](#), pyriform area, hippocampus complex, parasplenial [gyrus](#), [cingulate gyrus](#), subcallosal gyrus, [amygdala](#), [hypothalamus](#), and anterior thalamus (MacLean, 1952). MacLean used known anatomical connections between brain regions to identify the structures of his limbic system that were thought to be involved in emotion processing. The positioning of this system, particularly the hippocampus, between phylogenetically older and newer structures, was proposed to be optimal for associating visceral sensation and perceptions of the physical characteristics of external stimuli (MacLean, 1949). Today, the brain systems as described by Papez and MacLean are not considered to be accurate correlates of emotional processing. Nevertheless, at the heart of the limbic system is the amygdala, which has been known to be important for detecting the salience of environmental stimuli since early research by Kluver and Bucy (1939), who lesioned the amygdala in monkeys and found that these animals no longer showed fearful responses toward dangerous stimuli, such as snakes and more dominant monkeys. The amygdala is a complex [subcortical structure](#) consisting of more than a dozen subnuclei situated in the anterior portion of the [medial temporal lobe](#). These subnuclei can be grouped into

three main complexes. The largest of these complexes, the lateral nuclear complex, receives inputs from all sensory systems and is important for mediating emotion-related [behaviors](#) (Fanselow and LeDoux, 1999). The central complex contains the medial nucleus, which is the primary output region for emotional responses (LeDoux et al., 1988). Lastly, the smallest group is the cortical nucleus whose main inputs are from the [olfactory bulb](#) and [olfactory cortex](#) (McDonald, 1998). Since the amygdala is one of the earliest (nonsensory) structures to receive sensory input and receives inputs from all sensory modalities, it has been the focus of many studies examining the appraisal and recognition of emotional stimuli. The outputs of the amygdala extend to regions involved in autonomic responses and regions involved in perception, memory, cognition, and emotion (LeDoux, 2007). Many of these connections are related to the amygdala's role in emotional reactivity, which will be discussed in more detail in the following section. While the amygdala was initially studied for its role in fear conditioning, and was believed to be mostly involved in fear/negative emotion, more recent research suggests that the amygdala is a general salience or relevance detector (Sander et al., 2003). We will first focus on the convergence of sensory information in the amygdala and then discuss the role of the amygdala, as well as other structures, in emotional appraisal and recognition.

Convergence of Sensory Information in the Amygdala

As mentioned previously, the lateral nucleus is the primary input region into the amygdala and receives environmental information from all sensory modalities (Fanselow and LeDoux, 1999). There is evidence that sensory information reaches the amygdala through two routes: one for quick, but less discriminative responses, and one for slower more discriminative responses (LeDoux, 1996). According to LeDoux (1996), the slower and more discriminative route involves sensory information being relayed from the [sensory receptors](#), to the sensory thalamus, to the [sensory cortex](#), and then to the amygdala. This route is referred to as the “high-road.” The quicker, dirtier, route

starts the same, but involves direct projections from the sensory thalamus (or other subcortical structures) to the amygdala, bypassing the sensory cortex. This route is referred to as the “low-road.” The information relayed to the amygdala by the sensory thalamus has not been processed by the sensory cortex, and is therefore of lower resolution. In bypassing the sensory cortex, low-road information is thought to be quicker and allow the amygdala to initiate fast responses to important stimuli based off of less detailed low-level sensory information. Thus, the low-road acts to initiate an immediate “better safe than sorry” response. In contrast, high-road information receives higher resolution processing by the cortex resulting in a later, but more appropriate response (LeDoux, 1996).

Early evidence that the amygdala receives information both from the [sensory cortices](#) and sensory thalamus comes from animal [lesion studies](#). Researchers conditioned a rabbit to fear one tone by pairing it with a shock. A very similar tone was not paired with a shock. After repeated conditioning, the rabbit would display an increased heart rate to the conditioned tone, but not the similar tone. Following conditioning, the [auditory cortex](#) was lesioned and testing the fear response to the tone resumed. Once the rabbits were lesioned, they were unable to make the discrimination between the 2 tones and instead displayed fear responses to both stimuli (Schneiderman et al., 1974). This finding suggests that the cortex is needed only to make fine sensory discriminations, but the amygdala can still perform fear learning based off of the low-resolution sensory information sent from the thalamus (LeDoux, 1996). Similar results have been reported in rodent models measuring freezing [behavior](#) in fear conditioning paradigms (Phillips and LeDoux, 1992). Collectively, these results suggest that damage to the sensory cortex results in less specific fear learning. Yet, if the amygdala and sensory thalamus are still intact, less discriminative fear responses can still be learned—presumably through the low-road.

Research in humans has also provided evidence supporting these two routes to the amygdala. Patient G.Y. has [cortical blindness](#), which is blindness as a result of damage to the [visual cortex](#),

rather than ocular damage. Despite the lack of a conscious visual experience (i.e., blindness), G.Y. is still able to discriminate between emotion-relevant and neutral visual stimuli. Brain activity was recorded with fMRI while G.Y. was asked to make discriminations of visual stimuli in their blind hemifield. The fMRI results indicated that the amygdala and [superior colliculus](#) (a subcortical visual structure in the midbrain) were activated in response to the presentation of emotional stimuli in the blind hemifield. On the other hand, when emotional images were presented to the intact hemifield, areas of visual cortex were active. These results provide support for a subcortical pathway that bypassed the damaged visual cortex to provide the amygdala with low-resolution information about emotionally salient stimuli in the environment (Morris et al., 2001).

To approximate [blindsight](#) in healthy subjects, a “masking” procedure can be utilized to prevent conscious-level processing of a presented image. One group used this technique by presenting happy and fearful [faces](#) for 33 ms then immediately presenting a neutral [face](#) in the same spot for 167 ms; participants only reported seeing the neutral face. Performing this task in conjunction with fMRI has revealed that the amygdala is more active in response to masked fearful versus masked happy faces, again suggesting the amygdala plays a role in detecting important stimuli without the need for conscious awareness (Whalen et al., 1998). Findings of amygdala activity to masked threats have subsequently been replicated numerous times (Armony et al., 2005; Carlson et al., 2010; Carlson et al., 2009b; Liddell et al., 2005; Morris et al., 1998, 1999; Rauch et al., 2000; Sheline et al., 2001; Suslow et al., 2006; Whalen et al., 2004; Williams et al., 2009; Williams et al., 2005). Furthermore, masking studies have shown that amygdala activation to nonconscious visual threat is associated with activation in subcortical visual structures, such as the superior colliculus and [pulvinar nucleus](#) of the thalamus (Liddell et al., 2005; Morris et al., 1999). Taken together, the evidence from animal lesion, blindsight, and masking studies provides substantial support for a fast, but low-resolution, subcortical “low-road” to the amygdala (LeDoux, 1996;

Liddell et al., 2005; Morris et al., 2001; Pourtois et al., 2013; Tamietto and de Gelder, 2010; Whalen et al., 1998).

While evidence has mounted in support of a subcortical route to the amygdala, it is not universally accepted that this route is necessarily responsible for faster, less detailed, processing of emotional information. One recent theory that takes direct opposition against the two-route theory is the multiple wave hypothesis (Pessoa and Adolphs, 2010). Pessoa and Adolphs (2010) argue that evidence for a subcortical pathway that processes emotional stimuli faster than other stimuli is not sufficient for all aspects of emotional processing. Furthermore, given the speed of cortical processing, the necessity for a fast subcortical pathway is unclear. From the low-road perspective, the pulvinar is thought to relay low-resolution visual information to the amygdala.

However, some evidence suggests that the pulvinar may process high-resolution information (Greene and Oliva, 2009; Pessoa and Adolphs, 2010; Pessoa and Ungerleider, 2004). In opposition to the high and low-roads to the amygdala, the multiple wave theory proposes that many different routes exist for information to reach the amygdala. While information does come from the pulvinar, in the context of the multiple wave theory the pulvinar plays an important role in distributing high-resolution stimulus information to the amygdala.

In sum, there is not a singular accepted theory as to how sensory information reaches the amygdala, or what particular level of detail is relayed via different sensory routes to the amygdala. Nevertheless, the theories reviewed here acknowledge that both cortical and [subcortical structures](#) project to the amygdala. The lateral amygdala receives sensory inputs from somatosensory, visual, auditory, [taste](#), and olfactory sensory cortices as well as associated thalamic inputs (LeDoux, 1996, 2007). Despite an ongoing debate as to the number of routes and the exact nature of the information relayed by these routes, there is general consensus that the amygdala receives a vast amount of sensory information, which makes it perfectly anatomically suited for a role in emotional appraisal.

Emotional Appraisal and Recognition Processing

Within the Amygdala

Evidence that the amygdala is involved in emotional appraisal and recognition comes from studies of patients with amygdala damage. Perhaps the most well-known person with amygdala damage, and also one of neurology's most famous patients, is known as patient S.M. S.M.'s amygdala damage was due to Urbach–Weithe disease, a condition that causes nearly complete bilateral destruction of the amygdala, while sparing nearby hippocampus and cortical structures (Adolphs et al., 1994). Aside from her amygdala damage, S.M. lives a fairly normal life; she has been married, a normal IQ, a high school education, and is a single-mother of three healthy children. Her main symptom is that she has little to no capacity to show or feel the basic emotion of fear and thus has impairments in avoiding situations which are dangerous and is perhaps overtrusting and overfriendly in her [social interactions](#). Due to her rare condition, she has been the subject of extensive research on the amygdala and its role in emotional appraisal.

S.M.'s condition revealed an important role of the amygdala in the processing of facial affect (Adolphs et al., 1994). S.M. and 12 brain-damaged controls with similar IQ were shown facial expressions of six basic emotions (happiness, surprise, fear, anger, disgust, sadness), as well as neutral faces, and asked to rate each face according to several emotional adjectives. S.M.'s assessments differed dramatically from controls, consistently rating expressions of fear, anger, and surprise as less intense than any of the brain-damaged controls. S.M. also showed severe recognition impairment specific to fear: her ratings of fearful faces correlated less with normal ratings than those of any brain-damaged control. In contrast, her recognition of the unique identity of faces was fully preserved: she was able to learn new faces and perfectly identify familiar faces. The results suggest dissociation between neural processing of facial identity and facial affect and that they are likely maintained by anatomically separate neural systems. These findings in the patient S.M. have been replicated in a larger sample of patients with varying degrees of amygdala damage. All but three of the patients in this study had been previously

reported on, but had yet to be tested under the same experimental procedures. The patients with amygdala damage rated negative emotions (fear, anger, and disgust) lower than controls. Furthermore, the ratings from amygdala-damaged patients were again less correlated with the ratings of normal controls than the ratings of brain-damaged controls. The impaired recognition of fear intensity in the amygdala-damaged group suggests that it is involved in detecting emotional signals of threat or harm (Adolphs et al., 1999).

Additional evidence points to a role for the amygdala in [processing information](#) from the eyes when recognizing emotional facial expressions. While S.M.'s injury and subsequent functional losses are the result of amygdala damage, it has been determined that her inability to detect fear is the result of not looking at the eyes of faces. S.M. and a control group were both presented with approximately 3000 faces: half of which were fearful and half of which were happy. In each trial, only certain portions of the face were revealed. The participants identified whether the faces expressed happiness or fear. S.M. required nearly twice as much of the face to be exposed as controls to identify a fearful face; however, her recognition of happy faces was normal. A closer examination of the data revealed that S.M. failed to make use of information from the eye region whereas controls consistently used this information. Interestingly, using the same experimental set up, but changing the task to identifying gender, revealed that S.M. does use information from the eye region in the same way healthy controls do if the task is gender recognition. To further test the theory that the eyes may be necessary for normal emotion recognition, the researchers digitally erased the eyes from whole face images and had S.M. and the control subjects try to recognize the expressed emotion. Removing the eyes from the images did not affect S.M.'s recognition accuracy, but the control subjects had a decrease in accuracy. Subsequent tests using eye tracking revealed that S.M. spent less time looking at the eye region in emotional faces than healthy controls. The results from this series of experiments in the patient S.M. indicate that the ability to recognize fear requires

attention to the eye region and this process is mediated by the amygdala (Adolphs et al., 2005).

Early research on the amygdala focused primarily on its role in fear. However, it is now understood that the amygdala is involved in the processing of other affectively salient stimuli. For example, according to the multiple wave theory the amygdala is involved in processing abstract dimensions of information, such as salience, ambiguity, unpredictability, and other aspects of biological importance (Pessoa and Adolphs, 2010). In general, the amygdala has been shown to activate for both negatively valent emotional stimuli, such as bad odors, aversive images, and threatening images as well as positively valent emotional stimuli, such as images of pleasant animals, babies, nudes, appetizing food, and monetary reward (Carlson et al., 2011a; Hamann et al., 2002; Redouté et al., 2000; Walter et al., 2008; Zald and Pardo, 2000). The amygdala is preferentially involved in the processing of fearful faces, but also activates in response to other socially relevant stimuli, such as faces in general, faces with directional gaze, and the processing of one's own name (Kawashima et al., 1999; N'Diaye et al., 2009; Portas et al., 2000; Sander et al., 2003; Wicker et al., 2003b). Even emotionally neutral, but unusual (e.g., surrealist films), stimuli activate the amygdala (Hamann et al., 2002). To explicitly test the hypothesis that the amygdala is involved in the evaluation of motivationally relevant stimuli, researchers had participants make evaluations of both positive and negative famous names while amygdala activity was recorded with fMRI (e.g., Adolph Hitler, Paris Hilton, George Clooney, etc.; Cunningham et al., 2008). Amygdala activity was found in conditions where evaluations were made of all names and when making positive or negative evaluations of positive or negative names, respectively. Collectively, these findings dispute early theories that the amygdala was involved only in fear processing. Converging research now suggests that the amygdala is involved in stimulus relevance evaluation based on the organism's needs (Cunningham and Brosch, 2012; Hamann et al., 2002).

Emotional Appraisal and Recognition Processing

Beyond the Amygdala

Areas of the cortex also play a role in the recognition of emotions. Recognizing emotions, especially in other people, is an important aspect of social behavior. Without the ability to recognize that another human can feel pain and joy similar to oneself, a person would have a hard time fitting in with society. Many experiments examining the ability to recognize emotions, including experiments described here, use facial expressions as stimuli to determine whether someone can recognize an emotion. The emotions communicated by faces are communicated by the changeable aspects of the face, such as the eyes or mouth (Bassili, 1979). For instance, fearful faces can be characterized by a widening of the eyes, flaring nostrils, and gaping mouth (Susskind et al., 2008). Research suggests that the ability to recognize a facial identity and the ability to recognize the changeable aspects of a face involve separate neural systems. Face identification is related to the lateral [fusiform gyrus](#) whereas recognition of facial expression is related to the [superior temporal sulcus](#) (STS; Haxby et al., 2000; Hoffman and Haxby, 2000). A study using MEG found that responses in the STS occurred along with responses in the amygdala when judging the expression of an emotional face compared to a neutral face (Streit et al., 1999). Further evidence that a network involving the STS and amygdala is involved in the recognition of emotion in faces comes from fMRI and lesion studies (Campbell et al., 1990; Lahnakoski et al., 2012).

The STS has connections to many different areas of the brain involved in different dimensions of [social cognition](#). Of particular interest to this chapter are the connections from the STS to the amygdala. Researchers presented healthy subjects with videos that depicted different social features (faces, bodies, biological motion, goal-oriented action, emotion, social interaction, pain, and speech) while they underwent fMRI scans. The authors found that the anterior STS and the amygdala formed a network sensitive to speech and the communication of emotions through facial expressions and/or body language (Lahnakoski et al., 2012). In rhesus monkeys, it has also been found that ablation of the STS

leads to deficits in the ability to discriminate the direction of eye gaze, a result that is also found in humans with [prosopagnosia](#) (i.e., the inability to recognize faces; Campbell et al., 1990).

Damage to the [somatosensory cortex](#) can also lead to an inability to recognize emotion in others even when the amygdala is intact. One group of researchers examined 108 patients with [brain damage](#) to assess possible regions of cortex associated with deficits in the ability to recognize emotion. In two experiments, the brain-damaged patients along with controls were shown 6 blocks of the same 36 emotional faces (6 faces each of happiness, surprise, fear, anger, disgust, and sadness) and asked to rate the intensity of the emotion in one experiment and match the expression with the written name of the expression in the second experiment. In a third experiment, participants sorted a subset of 18 facial expressions (3 of each emotion) into emotion categories that were similar. The researchers divided the group in half based on intensity scores in experiment one and found that those in the bottom half (more impaired) had localized damage to the somatosensory cortex. When the groups were further divided into the top and bottom 25% of intensity rankings, localized somatosensory damage was found again. Examination of performance as a function of lesion location in the second and third experiments further revealed the necessity for intact somatosensory cortex for normal recognition of all emotions. A post hoc analysis of medical records found a correlation between impairment in emotion recognition and [somatic](#) sensation (Adolphs et al., 2000). Based on these results and results from other studies of STS function, the authors concluded that visual and somatosensory representations of emotions and the white matter connecting regions of the brain that support the representation of this information allow one to recognize the mental state of another by simulating the observed state in oneself (Adolphs et al., 1994; Adolphs et al., 2000; Adolphs et al., 2005; Campbell et al., 1990; Haxby et al., 2000; Lahnakoski et al., 2012).

Although the amygdala has been extensively studied in the context of negative emotions, it also plays an important role in

positive emotions and can be thought of as a general salience detector (Sander et al., 2003). The brain appears to also have a region that is primarily associated with reward processing—the [nucleus accumbens](#) of the [ventral striatum](#) (Knutson et al., 2001a; Kravitz et al., 2012; Olds and Milner, 1954). Early studies on reward and pleasure in the brain used a technique of electrical self-stimulation in rats (Olds, 1958; Olds and Milner, 1954). This technique involves placing an electrode into the brain of a rat. The wires leading into the electrode hang from the ceiling of a Skinner box to allow free movement by the animal. The Skinner box, a controlled environment used in animal behavior experiments, contains a lever that controls the electricity sent to the subject's brain and the subject is free to push the lever. Olds and Milner (1954) used this technique, implanting electrodes into different brain regions and then correlating bar presses and extinction of bar presses to electrode placement. The results indicated that electrode implantation in the septal region, beneath the [corpus callosum](#), resulted in the highest amount of bar presses. Furthermore, the results of self-stimulation were comparable with those of studies using typical reinforcers, such as food. A modern take on this study has used [optogenetic techniques](#) to stimulate [dopaminergic activity](#) in the [striatum](#) of rats (Kravitz et al., 2012). In this study, a rat was placed in a Skinner box with two levers, one of which did nothing and the other turned on a laser that, depending on experimental condition, would either stimulate excitatory D1 receptors or inhibitory D2 receptors. The results indicate that activation of D1 receptors increases the probability that the rat will respond again, whereas D2 activation results in the animal moving away from the lever and decreased probability of response (Kravitz et al., 2012). Thus, the striatum and dopamine may be involved in the detection of both rewarding and punishing stimuli.

An increase in [BOLD](#) signal has been found in the nucleus accumbens/ventral striatum in anticipation of increased reward using fMRI (Knutson et al., 2001a). In a seminal study, researchers presented participants with a task, during fMRI scans, in which a cue either signaled a small or larger monetary reward (gain \$0.20,

\$1, \$5), a small or larger monetary loss (lose \$0.20, \$1, \$5), or no monetary loss or gain. During conditions in which the cue stimulus signaled loss or gain, the subjects responded to a target appearing on screen for 160–260 ms. If they pressed the button while the square was on screen they either avoided the loss or received more money. The results of fMRI analysis indicated greater BOLD signals in the nucleus accumbens during anticipation of reward compared to no reward. An additional fMRI study revealed that the ventral striatum is related to predicted monetary reward versus nonreward outcomes (Knutson et al., 2001b). Similar fMRI activation in the ventral striatum has been observed in anticipation of other positive/rewarding stimuli such as erotic movie clips (Greenberg et al., 2015). Collectively, these findings provide evidence that the nucleus accumbens is active during the anticipation of reward, meaning it is involved in the appraisal and recognition of rewarding stimuli.

Appraisal of emotional stimuli and accurate recognition of the emotion are important aspects of survival as well as the more mundane aspects of daily life. In the case of S.M., damage to the amygdala resulted in an inability to recognize fear in faces, show normal fear responses, and a tendency to be more trustworthy and friendly than the normal person (Adolphs et al., 1998; Bechara et al., 1995). Thus, there are very real consequences as a result of damage to the amygdala. In addition to the amygdala, different cortical regions are also necessary for appraising emotional stimuli and recognizing emotions. The somatosensory cortex appears to be necessary for recognizing other's emotional expressions by simulating the feelings of others in ourselves (Adolphs et al., 2000). The STS is connected to the amygdala, which is important for processing facial expression and body language (Haxby et al., 2000). The nucleus accumbens also plays a role in the evaluation of emotional stimuli as it is involved in predicting rewarding outcomes (Knutson et al., 2001b). The amygdala is an important structure in the appraisal of environmental stimuli for emotional significance. However, other structures are also involved. For instance, the cortically generated N1 ERP

component can be modulated by both positive and negative stimuli (Weinberg and Hajcak, 2010). Thus, there are multiple and distributed regions in the brain for detecting and appraising the significance of emotional input and we have only introduced a few of these structures here.

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Chapter

Dashboard Effects Challenge Flow-Learning Assumption in Digital Instructional Games

2016, [Emotions, Technology, and Digital Games](#)

Debbie Denise Reese

Eustress and Performance

Video games provide player opportunity to explore and take chances in low-risk situations; e.g., an avatar may die, but the player walks away. Thus, one might assume gameplay causes less stress than comparable real-life situations. People are always under some degree of stress. Stress is the mechanism through which people adapt to activities and demands. Stress is “the nonspecific response of the body to any demand, whether it is caused by, or results in, pleasant or unpleasant conditions” (Selye, 2013, para 48). Demands may be physical, cognitive, or affective. Stress effects differ. Differential effects occur between stress agents, between individuals, and because of agent by individual interactions. Differences within individuals are caused by conditioning factors, which may be endogenous (e.g., [genetic predisposition](#), age, sex) or exogenous (e.g., hormones, drugs, diet). According to Selye,

Under the influence of such conditioning factors, a normally well-tolerated degree of stress can even become pathogenic, selectively affecting those parts of the body that are particularly sensitized both by those conditioning factors and by the specific effects of the eliciting agent, just as physical tensions of equal strength in different chains will break the particular link that is the weakest as a result of internal or external factors.

(Selye, 2013, para 36)

Selye (1974, 1975, 2013) established two types of stress. Bad stress, or distress, is debilitating. Good stress, which he termed “eustress,” is not. [Eustress](#) accompanies success and accomplishment.

During both [eustress](#) and distress the body undergoes virtually the same nonspecific responses to the various positive or negative stimuli acting upon it. However, the fact that eustress causes much less damage than distress graphically demonstrates that it is “how you take it” that determines, ultimately, whether you can adapt successfully to change.

(Selye, 2013, para 49)

Implication for game-based learning: by definition, stress reported by a player while performance improves (e.g., the player perseveres to conquer game goals) or reaches high levels of achievement would be categorized as eustress.

Seminal research conducted by Yerkes and Dodson (1908) and later replicated by each individually (Diamond, Campbell, Park, Halonen, & Zoladz, 2007), showed that performance is affected by the interaction between [emotionality](#) (e.g., stress or arousal) and the task (e.g., complexity, difficulty). When the task is relatively simple (e.g., a restricted range of cues or stimuli have high discriminability), the relationship between emotionality and performance is linear and positive. Strong emotionality can enhance performance. When a task is moderately-difficult or difficult, the relationship is curvilinear. Performance increases with emotionality until performance peaks at an optimal level. Higher levels of emotionality impair performance.

Implication for game-based learning: by application of Yerkes-Dodson, levels of high emotionality reported while performance improves (e.g., player perseveres to conquer game goals) or reaches high levels of achievement, must occur at optimal levels of emotionality or co-occur with a relatively easy task. If player logs indicate high performance and moderate or high task difficulty, then emotionality is assumed to be optimal.

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