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Did my emotions reach them? Emotional contagion during an investor pitch

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Emotional contagion during an investor pitch.

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Abstract

An investor pitch is a unique event to raise capital from investors for a company or project. To effectively secure the desired funds, entrepreneurs must comprehend the subconscious factors that impact the funding decisions of potential investors. For this reason, understanding the emotional contagion process within a pitch is important. This leads to the following research question; Does emotional contagion take place in an investor pitch? In this study, we aim to contribute to entrepreneurial literature and past work that examines the effect of emotions on funding. To achieve this we analyse the faces of both receivers and signallers in a pitch with the use of an emotion detection model and linear regression. Our results show no evidence that emotional contagion is taking place in investors' pitches. The performance of the emotion detection model is the main limiting factor for the results.

Introduction

“The best and most beautiful things in the world cannot be seen or even touched. They must be felt with the heart” — Helen Keller.

In the pursuit of funding for startups or businesses, one prevalent approach is to deliver an entrepreneurial pitch to venture capitalists or angel investors. Each year, numerous pitches are held so that companies can introduce their innovative ideas into the market. It is acknowledged that the emotional response of an investor plays a crucial role in the decision-making process, as highlighted in the entrepreneurial passion literature (Jiang et al., 2022). To effectively secure these funds it is important to understand the role of emotions in an investor pitch. This bachelor thesis aims to delve deeper into the role of emotions using emotional contagion theory.

Experiencing emotional contagion can be illustrated by encountering a happy individual whose radiant smile not only evokes a smile from you but also uplifts your mood. This change in mood influences general behaviour and funding behaviour (Schwarz et al., 2012) The emotional contagion process is mostly a subconscious process and happens in 3 stages; mimicry, feedback and contagion. These phenomena of mimicry and emotional contagion have been documented in numerous psychology studies (Hatfield et al., 1992, 1993, 2014) and can be used as a main theory to estimate the effect of emotions on funding (Raab et al., 2020). The main research question is: *Does emotional contagion take place during an investor pitch?*

To answer this question a dataset with both the faces of the pitchers and listeners is used. This is done through the utilisation of deep convolutional neural networks (CNNs) capable of automatically detecting social signals exchanged during human-to-human interactions. No evidence has been found that emotional contagion is taking place during an investor pitch. This might be due to limitations in the model, methods and data. If these limitations are resolved our study provides four potential contributions to the entrepreneurial literature.

Our first contribution is in signalling theory in entrepreneurship research in the context of an investor pitch. Recent work encourages researchers to utilise the taxonomy developed by the authors to identify additional relevant relationships that can advance signalling theory in entrepreneurship contexts (Bafera & Kleinert, 2022). In any signalling process, there must be a signaler, signal, receiver, and environment, each comprising multiple signal constructs. However, studies often focus on one specific aspect of the signalling process. Researchers are encouraged to take a more holistic perspective, including multiple signal constructs, and account for how they relate (Bafera & Kleinert, 2022). In this study emotional contagion, with the use of multiple aspects of the signalling processes will be investigated. More specifically we will investigate the receiver and signaller interactions within an entrepreneurial pitch. This will be done to deepen the understanding of a higher-level construct, the emotional contagion process which is composed of multiple signal constructs.

Our second contribution is addressing the limitations of Raab et al. (2020). Raab determined that facial emotional expressions shown in pictures on a crowdfunding platform have a contagious effect on backers. This contagious effect is measured by the change in the behaviour of an individual. This behavioural change is measured by observing differences in funding. As discussed in the limitations of Raab et al. (2020), there is no empirical evidence that showing a happy face triggers the emotional contagion process. They assume that emotional contagion provides an adequate lens to explain the observed change in behaviour. However, Raab et al. (2020) cannot rule out the possibility that alternative explanations for the phenomenon exist. The goal of this study is to rule out alternative explanations. A difference is that emotional contagion will be studied in a different signalling environment. Instead of examining emotional contagion in crowdfunding videos, it will be examined in pitches.

Our third contribution is by addressing limitations in Warnick et al. (2021). Warnick's et al. (2021) study is closely related to Raab et al. (2020), only the setting is different. Warnick et al. (2021) examined 489 pitches using computer-aided facial expression analysis and focused on the four basic emotions. In the limitations of Warnick et al. (2021), they emphasise that there is no examination of emotions on experience, only on expression. In this study, we aim to address this gap of examination of emotions on experience by using emotional contagion theory. This will be done with the use of a unique pitching dataset that combines both the signaller and receiver constructs for an examination of emotions on experience. This methodology and context-specific evidence of emotional contagion theory could be used in future work for a better explanation of the effect of emotions on experience.

Our final contribution is to the research agenda of the entrepreneurial passion literature (Newman et al., 2019). Past work has begun to examine how entrepreneurial passion influences others around them (e.g., Breugst et al., 2012; Davis et al., 2017). In the Entrepreneurial Passion research agenda, the authors suggest that the emotional contagion theory could help understand the processes by which entrepreneurial passion might be appraised by or affect others. In this research the entrepreneurial passion construct is not examined specifically, however the emotional contagion in a pitching context where entrepreneurs show entrepreneurial passion is examined. By providing more insights into the emotional contingency process in entrepreneurial pitch a contribution is made to the entrepreneurial passion research agenda.

Theoretical background

Related work

Within the entrepreneurship literature there are multiple studies that examine the effect of emotions on funding. This study focuses on the transfer of emotions using emotion contagion theory, which is not researched in the entrepreneurship literature. In this section an overview is provided of competing theories and related work that investigates the effect of emotions on funding, Table 1 summarises the results.

Affective events theory (Weiss et al., 1996) proposes that affective work behaviours are explained by employee mood and emotions, while cognitive-based behaviours are the best predictors of job satisfaction. Using this theory Davis et al. (2017) found that the passion displayed by the founders in the introductory video can impact the amount of intended funding. In a pitching competitions context, Stroe et al. (2020) revealed with the use of facial expression analysis a positive influence of fear of failure on negative affect. In these previous studies, emotions influence behaviour. We propose that emotional contagion theory could be used as an alternative explanation in these studies.

With the use of the Unimodel of persuasion as a foundational theory, Zhou et al. (2018) employed text analysis and determined that utilising emotional words can positively influence funding. However, their research also indicated that excessive use of emotional language may have a negative impact on funding outcomes. This indicates that showing certain emotions influences behaviour according to the emotional contagion process.

Warnick et al. (2021) showed with the use of basic emotion theory (Keltner et al., 2019) and the dual threshold model of anger in organisation (Geddes et al., 2007) that showing certain emotions can improve funding (Warnick et al., 2021). This has been done with the use of 489 pitches and computer-aided facial expressions. The frequency of entrepreneurs' facial expressions of happiness, anger, and fear have an inverted U-shaped relationship with funding. The justification for the spread of emotions is based on the fact that by displaying specific facial expressions of emotion, individuals aim to influence others in a manner that benefits themselves (Russell et al., 2003). An alternative justification for this research would be that the emotional contagion process is taking place.

Passion contagion is the process where passion is contagious and spread to others (Cardon, 2008). On funding websites such as Kickstarter and Indiegogo researchers found a positive relationship between displayed entrepreneurial passion and the funding amount (Li et al., 2017) indicating that passion contagion takes place. This was motivated by the use of an observational analysis on crowdfunding platforms. In summary, if passion was observed in the introduction of the video, the research expected a different funding amount and willingness to share. They further motivated that passion contagion is taking place with the use of a between-subjects experiment (Li et al., 2017). In our study, a facial expression analysis is conducted instead of a survey, where the facial expressions of both the signal and receiver entities are used.

Emotional contagion theory (Hatfield et al., 1993) is used as a main theory in different studies to understand the impact of emotions on funding. The facial expressions depicted in Kickstarter project pictures have a contagious effect on backers, shaping their reactions (Raab et al., 2020). Demonstrating emotions like happiness and sadness has been found to boost funding. While as a persuasion tool, emotions should nevertheless be used judiciously since high intensities of facial emotional expressions negatively affect the funding decision (Raab et al., 2020). Jiang et al. (2022) found similar results for displaying enthusiasm; displaying enthusiasm may not always be effective for entrepreneurs because there are both positive and negative pathways underlying the influence of displayed enthusiasm on funders. Balancing genuine emotions is key to funding success.

Theory	Work	Findings
Affective events (Weiss et al., 1996)	Davis et al. (2017)	Passion displayed can impact funding.
	Stroe et al. (2020)	Facial expression has a positive influence of fear of failure on negative affect.
Unimodel of persuasion (Kruglanski & Thompson, 1999)	Zhou et al. (2018)	Utilising emotional words can positively influence funding.
Basic emotion theory (Keltner et al., 2019) and the Dual threshold model of anger (Geddes et al., 2007)	Warnick et al., (2021)	The frequency of entrepreneurs' facial expression of happiness, anger, and fear have an inverted U-shaped relationship with funding.
Passion contagion (Cardon, 2008)	Li et al. (2017)	There is a positive relationship between displayed entrepreneurial passion and the funding amount.
Emotional contagion (Hatfield et al., 1993)	Raab et al. (2020)	Emotions like happiness and sadness have been found to boost funding.
	Jiang et al. (2022)	Displaying enthusiasm may not always be effective because there are both positive and negative pathways.

Table 1. Overview of findings and theories.

Theoretical framework

In order to investigate the occurrence of emotional contagion during an investor pitch, it is essential to understand the emotional contagion theory while keeping the context of a pitch in mind. Emotional contagion theory is from social psychology (Hatfield et al. 1993). The theory suggests that a person's emotions are contagious. It is mostly a subconscious process and happens in 3 stages; mimicry, feedback and contagion (see Fig. 1).

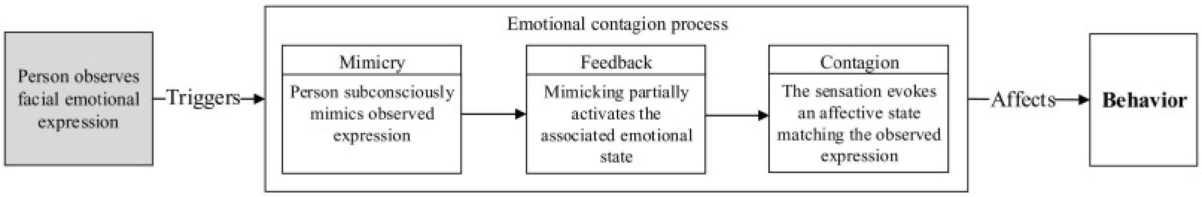

Fig. 1. Overview of emotional contagion.

Mimicry

Emotional contagion starts with the mimicry stage. Typically, individuals have a tendency to mimic and align their non-verbal behaviour, including their emotional expressions, with those of the person they are observing (Hatfield et al., 2014). Individuals tend to mimic behaviours such as yawing, smiling or looking happy when seeing another person executing that behaviour. Insights from neuroscience suggest that simply observing another person's facial expressions activates an autonomic and somatic response, by the observer (Hatfield et al., 2014). In the context of investor pitch the pitcher would for example smile and the panel members will automatically mimic the facial expression.

Feedback

After mimicking a person's smile, it begins to influence the observer's emotional experience. The neural feedback from the muscles flows to the brain triggering the emotional brain systems of the observer, which partially activates the associated emotional state in himself/herself to infer the expressed emotion (Prochazkova & Kret, 2017).

Contagion

After the emotional systems of the brain are activated and mentally processed, the receiver (observer) will start to feel emotions. Instead of only looking happy and smiling, the person will also feel happy. In summary, a person mirrors an expression (mimicry) and then sends the feedback to the emotional part of the brain (feedback). After receiving the feedback and processing it the person starts to feel the emotions (contagion). The emotions on the face of the receiver should match the receiver's internal affective state. This change in emotional state can impact the observer's attitude and decision-making behaviour (Hatfield et al., 2014). Previous studies on decision-making have shown that immediate emotions, experienced at the moment of making a decision, can influence the decision-makers expectations regarding the likelihood or desirability of outcomes and can alter the way they process those outcomes (Loewenstein et al., 2003). For instance, a state of happiness is linked to more optimistic judgments.

Determinants of emotional contagion

Broad research has found that there are mainly three determinants of emotional contagion. First of all emotional contagion is more likely to happen if the individuals love each other or share the same goal (Kimura et al., 2008). Secondly, emotions are more contagious if the event is ambiguous in nature (Van Kleef et al., 2015). An investor pitch is an ambiguous event since there is a lot of unknown information. The pitcher is able to give extra information about his intent using emotional contagion. Thirdly is that the kind and intensity of the emotion influence the contagion (Loewenstein et al., 2003). Literature suggests that some kinds of emotions are more contagious in nature than others.

Hypothesis development

Based on this Theoretical framework, we propose a research model that seeks to investigate the process of emotional contagion in a pitch, taking into account the three determinants.

To determine if emotional contagion takes place in an investor pitch, we first contextualise the emotional contagion process. While observing investors' pitches, investors notice the facial emotional expressions displayed during the pitches. According to the emotional contagion theory, this automatically triggers the initial stage of the emotional contagion process, wherein investors unconsciously begin to imitate the observed facial expressions (Hatfield et al., 2014). In the second stage, the neural feedback from muscular movements activates the emotional brain systems of the investors, stimulating the corresponding affective state to infer the emotion being expressed. This activity eventually leads the investors to experience an emotional state that aligns with the observed facial expression in the final stage (Prochazkova & Kret, 2017). This change in emotional state in return should be reflected by the change in particular facial expressions of the investor (Loewenstein et al., 2003). For example when the pitcher expresses happy facial expressions throughout the entire pitch a change in the emotional state of the investor is expected. Nevertheless as mentioned in the Theoretical Framework the emotional contagion process depends upon three main determinants that should be accounted for and are crucial for our research model and hypothesis.

The first determinant is that emotions are more likely to happen if individuals share the same goal or love each other (Kimura et al., 2008). In a pitching context, this could mean that the pitcher coincidently shares the same goal as the investor, making his emotions more contagious to certain investors. To account for this bias caused by this determinant, randomization should be used. In the observational dataset, we will have one pitcher and three listeners, meaning that on average all the listeners have the same goal. To ensure even further randomization we will make use of two panel groups of listeners for all the pitches. This method allows us to minimise the effects of the first determinant and concentrate more on the effects caused by the third determinant.

The second determinant in the emotional contagion process is that emotions are more likely to be contagious if the event is ambiguous in nature (Van Kleef et al., 2015). An investor pitch is an ambiguous event in nature because it is unknown what is going to happen during the pitch. For example, the listeners don't know the intent of the pitcher, his background and the next words he is going to articulate. Next to that, there is asymmetric information since the pitcher knows more about the pitch and his ideas than the investor. This makes the investor pitch an event where emotions are easier transferred through the emotional contagion making it very fitting to study emotional contagion.

The third determinant is that the kind and frequency of an emotion determines the emotional contagion process (Loewenstein et al., 2003). This determinant is crucial since it shapes our hypothesis and research model. The idea is that by changing variables within this determinant changes will be observed, meaning that emotional contagion is taking place in an investor pitch. Within the context of investor pitches, this determinant manifests itself by the kind and frequency of the emotions a pitcher signals during the pitch to the panel members.

Using these properties of the third determinant, we want to prove that emotional contagion is taking place inside an investor pitch. For developing the hypothesis the problem is divided into two parts; the signaller and receiver part. The emotions of the signaller (the pitcher) should influence the emotions of the receiver (the panel member). According to the frequency dimension of the third determinant more emotional contagion should take place when the pitcher signals a higher frequency of emotions (on average) as opposed to a lower frequency of emotions (on average). Facial expressions are recognized as a prominent form of communicating emotions (Russell et al., 2003). Combining these two statements, the signaller part of our hypothesis becomes: *The average frequency of facial expressions a pitcher signals influences the receiver.*
The third determinant also states that the kind of emotions determines the amount of emotional contagion that is taking place. To keep this variable within the third determinant constant, we focus only on happy facial expressions since it represents a basic emotion (Keltner et al., 2019). Based on this our hypothesis for the signaler part becomes: *The average frequency of happy facial expressions a pitcher signals influences the receiver.*

For the receiver (panel member) part of the emotional contagion process, the change in his internal affective state has to be measured. When the pitcher signals more happy emotions throughout the pitch we hypothesise with the use of emotional contagion theory (Hatfield et al., 1993) that the receiver's internal affective state becomes happier during the pitch. This change of internal affective state can be measured with the use of a proxy variable, the change of facial expressions throughout the pitch. A person being in a happier effective state expresses more facial expressions of happiness (Russell et al., 2003). This change in facial expressions can be measured by comparing the frequency of happy facial expressions from the investor at the end of the pitch compared to the beginning of the pitch. Thus the complete hypothesis becomes: *The* average frequency of happy facial expressions *a pitcher signals influences the frequency of happy facial expressions from the investor at the end of the pitch compared to the beginning of the pitch.*

Methods and data

To evaluate the hypothesis a small dataset containing 19 pitches will be used. For each frame within a pitch, the face will be detected and then the emotion of the facial expression will be extracted by our models. After that, the emotion of the facial expressions will be analysed using an OLS model. In Figure 2 an overview of this process is presented.

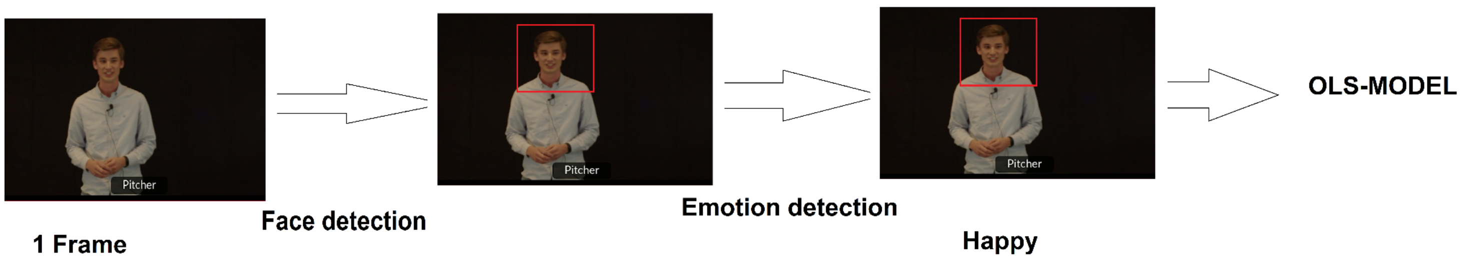

Fig. 2. An overview of data processing.

Entrepreneurial pitch dataset

The data is from an entrepreneurial pitch competition held at the Jheronimus Academy of Data Science in 's-Hertogenbosch in early December 2022. The pitchers are master's university students who participated in a competition as part of a course on entrepreneurship in Data Science.

The dataset contains 19 pitches and each pitch is evaluated by one panel of three members. In total, there are two different panels, consisting of six experienced investors. The special property of this dataset is that during the pitches the faces of the panel members and pitches are recorded in high quality (Fig. 3). The pitchers are held in a black room so that it contains minimal environmental noise (Fig. 4). The pitches were about 3-4 minutes long.

During the data collection of the course, care was taken to ensure the protection of the privacy of the students and investors. Each participating student and investor had to indicate their preferences concerning the collection. W.J. Liebregts provided the dataset upon signing a non-disclosure agreement.

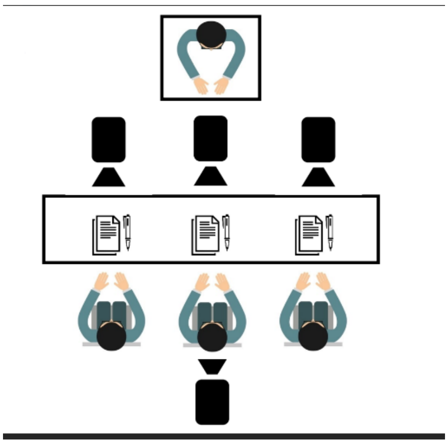

Fig. 3. Schematic set-up (W.J. Liebregts).

Fig. 4. Example pitch set-up (From another pitching event).

Face-detection

To automatically detect and capture the faces of individuals in each frame, a library called 'Bleedfacedetector' was used. The Bleedfacedector library contains a wide range of methods for face-detection that have been well documented. The facial detection model used for this study is called Single Shot Multibox Detector (SSD). This model is a foundational facial detection model from the year 2015. This model has been chosen because it is well-documented and therefore easier to implement. This model is compared to other facial detection techniques such as MediaPipe, Dual Shot Face Detector and YuNet around average in the accuracy benchmark (Varun, 2023). The SSD approach relies on a feed-forward convolutional network to generate a predetermined set of bounding boxes and scores, indicating the existence of object class instances within those boxes (Fig. 5). This is followed by a non-maximum suppression to produce the final detections (Liu et al., 2016). To improve the accuracy of the facial detection method in this use case padding to the faces was added.

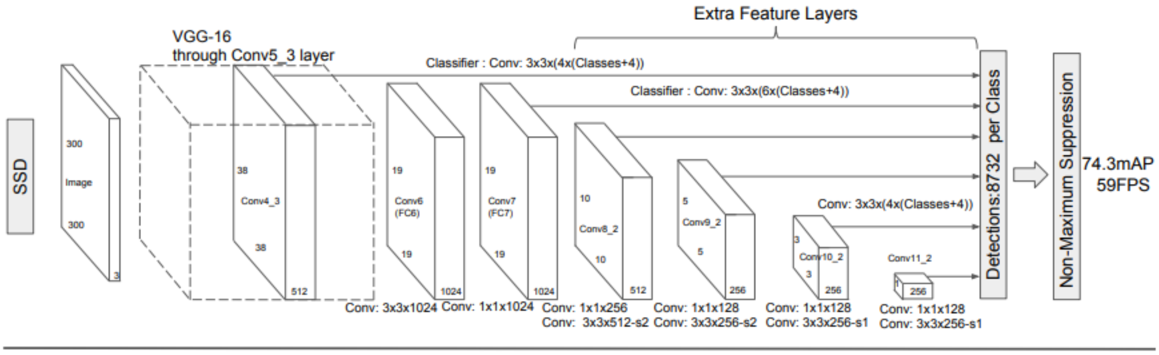

Fig. 5. SSD architecture (Liu et al., 2016)

Emotion detection (CNN)

After detection of a face using the SSD model in a single image, the face is passed through a pre-trained deep convolutional neural network (Barsoum et al., 2016) for emotion detection. This Barsoum model was trained on the FER+ dataset which was manually labelled by 10 crowd-sourced taggers for the specific purpose of creating this model. The images were labelled into one of eight emotion types: neutral, happiness, surprise, sadness, anger, disgust, fear, and contempt. Currently, there are better performing models, the Barsoum model has an 85% accuracy while state-of-the-art models such as ResNet-50 outperform the Barsoum model with 92.30% accuracy (Gupta et al., 2022). Yet the Barsoum model was chosen because it is better documented and available in an ONNX formatting style making it easier to implement with Python. When comparing the Barsoum model to a standard CNN architecture. The difference is that the Bassoum model uses the advantage of multiple labels per image to boost its classification accuracy. In Figure 6 an overview of the network's architecture is displayed.

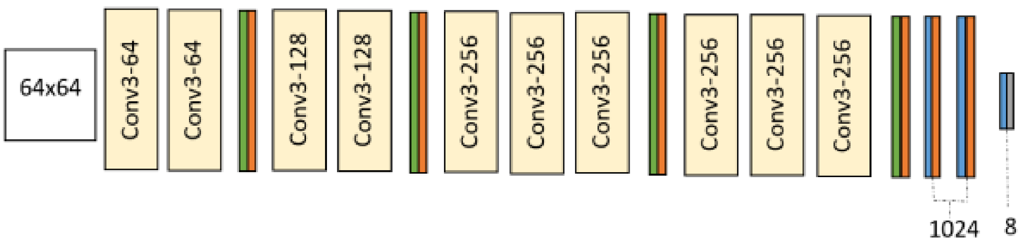

Fig. 6. Custom VGG13 network: yellow, green, orange, blue and grey are convolution, max pooling, dropout, fully connected and soft-max layer (Barsoum et al., 2016)

Measures

In this section we define the measures for *hypothesis*: *The* average frequency of happy facial expressions *a pitcher signals influences the frequency of happy facial expressions from the investor at the end of the pitch compared to the beginning of the pitch.*

Dependent variable

To analyse our hypothesis the independent variable will be the change in a panel member's amount of happy facial expressions. This is defined as the amount of happy facial expressions from the investor at the end of the pitch compared to the beginning of the pitch. The amount of happy facial expressions have a linear relationship with the frequency of facial expressions because the same amount of facial expressions are used for the end and beginning of each pitch. For our current model, a time period of 15 seconds is selected for the beginning and end of the pitch. We expect the sample to be long enough to measure significant effects. In addition to a time period of 15 seconds time periods are varied from 10 to 30 seconds as robustness checks. The change in a panel members amount of happy facial expressions is calculated according to the equation:

$$\Delta facial\ expressions\ panel\ member\ =\ happy\ facial\ expressions\ at\ beginning\ of\ a\ pitch\ from\ a\ panel\ member$$
$$-\ happy\ facial\ expressions\ at\ the\ end\ of\ a\ pitch\ from\ a\ panel\ member$$

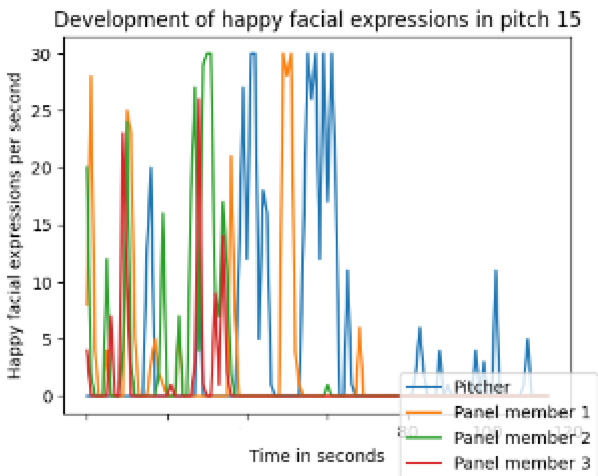

Fig 7. Development of happy facial expressions in pitch 15

In essence the amount of happy facial expressions is measured at the beginning and at the end of the pitch to get the $\Delta facial\ expressions\ panel\ member$. In Figure 7, an example of our model output for the amount of happy facial expression per second is shown for pitch 15.

Independent variable

Our dependent variable will be the *pitcher's sentiment*. It is defined as the average frequency of happy facial expressions a pitcher signals during 1 pitch. The facial expressions of the pitcher are extracted using the emotion detection model. In each frame, we count the classification of happy facial expressions and the facial expressions of other classes. Then we calculate the percentages of happy facial expressions by comparing them with all facial expressions creating the sentiment. The sentiment can be used to compare pitches of different lengths. The *pitcher's sentiment* is calculated according to the following equation:

$$sentiment\ pitcher = \frac{amount\ of\ happy\ facial\ expressions\ of\ the\ pitcher\ in\ the\ entire\ pitch}{amount\ of\ all\ classes\ \ of\ facial\ expressions\ of\ the\ pitcher\ in\ the\ entire\ \ pitch}$$

Control variables

Several control variables are included into the research model. First of all, the gender of each pitcher and panel member is controlled. This prevents unwanted effects that could happen due to gender differences (Doherty et al., 1995). To control for effects that might be caused due to differences in the amount of information inside the pitches we controlled for the length of each pitch. Next to that, there might be some effects caused by the order in watching pitches. A panel member could for example be more fatigued after having watched 3 pitches beforehand. The speaking order could also matter (Lesko & Schneider, 1978). This will be controlled by using the *number of pitches watched before*. Table 2 presents the control variables.

Variable	Description	Mean	Std	Min	Max
Length of a pitch in seconds	The time a pitch lasts in seconds.	185.58	43.45	116	277
Gender of pitcher, male=1, else=0	The gender of the pitcher, male=0 else=0.	0.74	0.44	0	1
Gender of listener, male=1, else=0	The gender of the panel member, male=1 else=0.	0.84	0.37	0	1
Number of pitches watched before	The number of pitches the panel member has watched beforehand.	4.26	2.77	0	9

Table 2. The control variables.

OLS model

To measure if emotional contagion is taking place in an investor pitch, the following OLS model is constructed using the controls, dependent and independent variables from the previous sections:

$$\Delta facial\ expressions\ panel\ member_i = \beta_0 + \beta_1 \times sentiment\ pitcher_i + Controls_i + \epsilon$$

Where:

$\Delta\ Facial\ expressions\ panel\ member$, concerns the change in facial expressions.

β_0, concerns our intercept.

β_1, concerns our slope.

$Sentiment\ pitcher$, concerns the sentiment of the pitcher.

ϵ, concerns the error term.

$Controls$, concerns the control variables mentioned earlier.

i, concerns our samples, 19 pitches in this case.

Results

Results

Table 3 summarises the results of our hierarchical regression analysis, model 1 only contains the control variables for the time period (=15 seconds). The *gender of the pitcher* variable shows no statistically significant results in the control group which is in line with other studies (Warnick et al., 2021). In addition to that, *the length of a pitch*, *number of pitches watched before* and *gender of the listener* show no statistically significant results in the control group.

Model 2 includes the independent variable of interest *sentiment pitcher.* The results show no statistical significance for the independent variable of interest. This indicates that in the analysis the *sentiment of the pitcher* does not impact the emotional *contagion* process. There is not enough evidence to reject our hypothesis. The results are not in line with related work (Li et al., 2017, Raab et al., 2020, Jiang et al., 2022). Next to that model 2 suggest that the *gender of the pitcher* a significant predictor is for finding the $\Delta facial\ expressions\ panel\ member$. This is not in line with previous studies (Warnick et al., 2021).

Variable	Model 1,t=15		Model 2,t=15	
	Coef.	***SE***	**Coeff.**	***SE***
Sentiment pitcher			58.71	71.30
Length of a pitch in seconds	-0.05	0.18	-0.10	0.19
Number of pitches watched before	3.52	2.75	3.65	2.76
Gender of pitcher, male=1, else=0	28.23	17.63	34.99*	19.50*
Gender of listener, male=1, else=0	-4.96	20.89	-2.85	21.11
Adjusted R2	2.211e-05		-0.00621	

Table 3. Hierarchical regression analysis. Notes: * $p < .05$; ** $p < .01$; *** $p < .001$; n = 57

Robustness checks

We conducted robustness checks (Table 4) to rule out alternative explanations for our results. The time was varied, from the beginning and end of a pitch from 10 to 30 seconds. This is to ensure that there is no bias created due to the cutoff point.

Model 3-6 contains all variables, the independent and control variables for different time periods. The results show no statistical significance for the independent variable of interest, *sentiment pitcher* across the different models. After running our robustness checks there is still not enough evidence to reject our hypothesis. Our robustness checks still suggest that the *gender of the pitcher* a significant predictor for $\Delta facial\ expressions_{panel\ member}$ is. Which is not inline with Warnick et al. (2021).

In addition to that model 5-6 suggest that the variable; *number of pitches watched before* a significant predictor is for the $\Delta facial\ expressions_{panel\ member}$. This result suggests that if a panel member has watched more pitches beforehand he will change his facial expressions more frequently.

Furthermore, model 6 suggests that *the gender of the listener* a significant predictor is for the $\Delta facial\ expressions_{panel\ member}$. This is probably the result of an individual bias, not caused by the gender but by the individual entity itself. After re-evaluating the dataset, it is concluded that the gender female is fully correlated with a specific panel member because only one specific female listener was present in the dataset. A possible explanation for that only model 6 is able to pick up this bias, is that it has the highest amount of observations.

Variable	Model 3,$_{t=10}$		Model 4,$_{t=20}$		Model 5,$_{t=25}$		Model 6,$_{t=30}$	
	Coef.	**SE**	**Coeff.**	***SE***	**Coef.**	***SE***	**Coef.**	***SE***
Sentiment pitcher	86.83	66.50	26.68	71.81	-22.22	75.68	-58.31	83.77
Length of a pitch in seconds	-0.21	0.18	-0.03	0.19	0.08	0.20	0.27	0.22
Number of pitches watched	2.85	2.58	4.58	2.78	5.99**	2.93**	7.13**	3.25***
Gender of pitcher, male=1, else=0	32.14*	18.19*	38.34*	19.64*	43.48**	20.70**	55.37**	22.91**
Gender of listener, male=1, else=0	1.96	19.69	-12.81	21.26	-31.35	22.41	-49.34*	24.80*
Adjusted R2	-0.003936		0.2674		0.1046		0.1924	

Table 4. Robustness checks. Notes: * $p < .05$; ** $p < .01$; *** $p < .001$; n = 57

Discussion

In conclusion, there was not enough evidence to determine if emotional contagion takes place in an investor pitch. The results from our OLS model and robustness checks indicate that the *sentiment of the pitcher* does not influence the $\Delta facial\ expressions\ panel\ member$. Being a male pitcher influences the $\Delta facial\ expressions\ panel\ member$. Possible explanations for these results are model, methodological and data limitations.

Model limitations

The biggest limitation of this study is the model performance. First of all the facial detection model used for this study seems to be having around the same performance as the literature suggests. Unfortunately, the emotion detection model seemed to bottleneck the performance and results found in this study.

The SDD (facial detection technique) technique works very well for this dataset and task. After inspecting the model outputs, most faces were detected correctly. In around 5% of the frames, no face was detected while a face should have been detected. This is within the expected range from the literature where SSD performance is around 76.9 % mAP (Liu et al., 2016). The faces that were forgotten are distributed in such a way that it doesn't impact the final results. The distribution of missing faces was throughout the entire pitch and not in a specific crucial area of the pitch such as the beginning of the pitch.

The emotion detection model, a convolution neural network from Basourm, was used to detect emotions. The model ended up performing badly on this dataset, an accuracy of around 20% is estimated. This is significantly lower than the 85% accuracy according to the literature (Barsoum et al., 2016). A manual evaluation of the model, using real-time camera data, did result in acceptable accuracy. This bad performance of the emotion detection model for this dataset has two potential causes. Firstly due to human error in the implementation code. The implementation code hasn't been reviewed by other people. In this implementation, most testing was done, by only using frames of pictures not entire videos. More testing of the implementation code is needed, especially with other video data sets. Secondly, another potential cause for the model not performing well could be that it does not generalise well towards this dataset. This can be accounted for by using transfer learning and manually labelling a part of the dataset.

Another method for improving the emotion detection model is using a fundamentally different technique. Psychology (Mui et al., 2018) studies and related work (Warnick et al., 2021) use the Facial Action Coding System (FACS) (Ekman et al., 1978) to focus on particular activation regions such as the AU 6 and AU 12 of the face. After that, the specific regions are used to define happiness or smile mimicry. This way of detecting facial expressions is more precise since it focuses more on particular motor regions which are well-defined. A limitation of using a CNN is that it correlates the entire face to emotion, not showing how it got to a particular result. The activation region method is more transparent.

Data limitations

Our results from the robustness checks suggest that the *gender of the pitcher* and *listener* a significant predictor is for the $\Delta facial\ expressions_{panel\ member}$. A possible explanation for this is that there are too few unique females in our sample population (n=4). There is only 1 female panel member and 3 female pitchers. This could result in a bias caused by the combined entity differences and not the gender itself. The most robust solution to this problem is to increase the sample size to have more females. In addition, an analysis using stratified sampling can be done to compare the results with and without stratified sampling. Next to gender, *the number of pitches watched before* is a significant predictor for the $\Delta facial\ expressions_{panel\ member}$. A potential explanation for this is that the variable; *number of pitches watched before* highly correlated is with the gender of the pitch resulting in a bias. Another explanation could be that speak-order effects are at play (Lesko et al., 1978). Additional analysis is required to verify these explanations.

Methodological limitations

Next to the limitations caused by the data there are three methodological limitations. Firstly, an important consideration regarding our methodology is the assumption that emotional contagion primarily occurs from the pitcher to the panel members. However, panel members may contribute to emotional contagion. When working in a panel, members look at each other's reactions to make a judgement (Barsade, 2002). The OLS modelling approach doesn't take into account these within-group effects that could take place. An alternative approach to using OLS is to construct a multi-level model with at level 1 the pitches and at level 2 different panel members. When executed on a large enough dataset this could regulate the emotion contagion process between panel members. In addition to that, using a multi-level model could regulate other unknown biases and effects that could potentially be taking place within a level.

Secondly, an observational-based research methodology for understanding the emotion contagion process within pitch might lead to imprecise results because of confounding variable bias. Various studies use an experimental setup to find out if emotional contagion is taking place (Dai & Hu, 2018, Mui et al., 2018). The benefit of using an experimental setup is that it allows control for certain interactions, and makes the study more focused. In addition, it facilitates the possibility of using data collection in multiple ways, one could survey the joviality before the pitch and after the pitch to measure the internal state of the listeners (Mui et al., 2018).

Thirdly, our method to measure the change in the internal affective state of a panel member might be too simplistic. Currently, our dependent variable is the $\Delta facial\ expressions_{panel\ member}$, where we compare the changes from the beginning of the pitch towards the end. In future work, it would be better to conduct an analysis using more levels of emotions. Instead of comparing the changes in facial expressions throughout the entire pitch the changes of facial expressions in smaller intervals could be compared. For example, how does $\Delta facial\ expressions_{panel\ member}$ change every 30 seconds within a pitch given a *pitcher's sentiment* in that specific interval?

Research directions

A further research avenue is addressing some of the limitations found in this study. Improving the emotion detection model while also conducting surveys to measure emotional contagion could produce interesting results. In addition to facial expressions other means of communication could be used to measure contagion, emotions can also be conveyed through different verbal and nonverbal channels. Nonverbal cues like gestures, physical contact and eye contact all play important roles in shaping how others perceive and respond to our emotions (Clarke et al., 2019). Exploring these signals of emotions in the context of entrepreneurship and how they interact with each other would be beneficial for future research.

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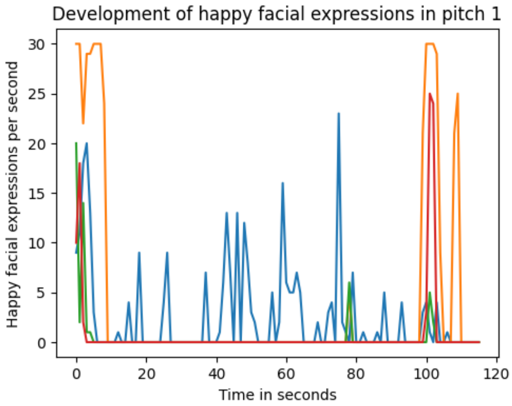
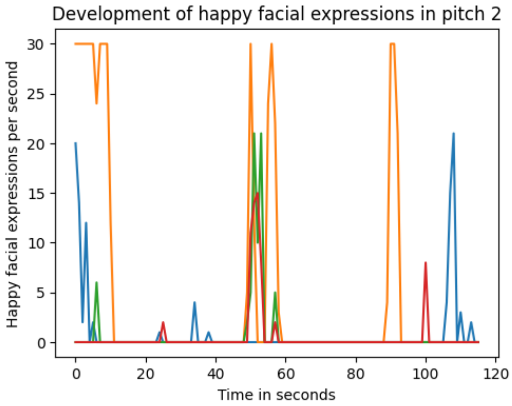
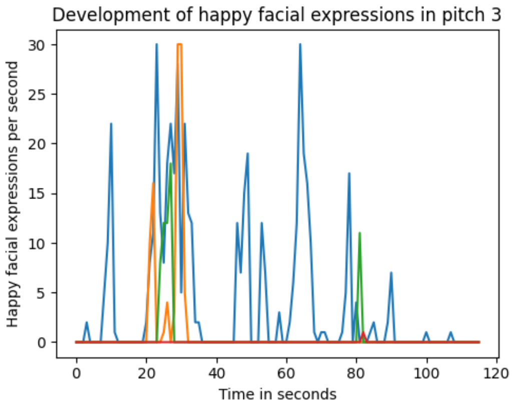
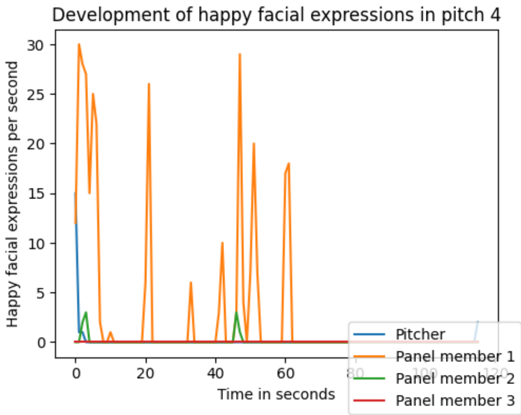
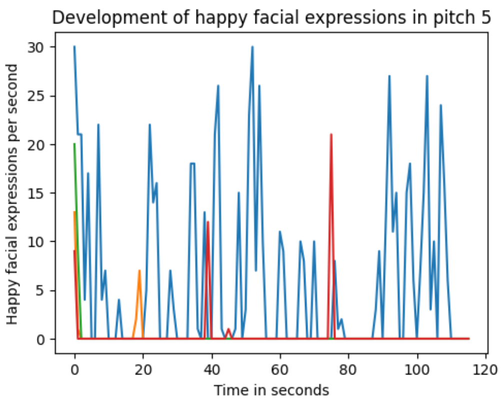
Appendix

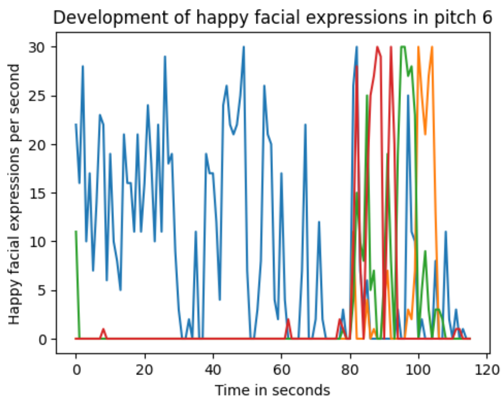

Development of happy facial expressions in pitch 1
Happy facial expressions per second
Time in seconds

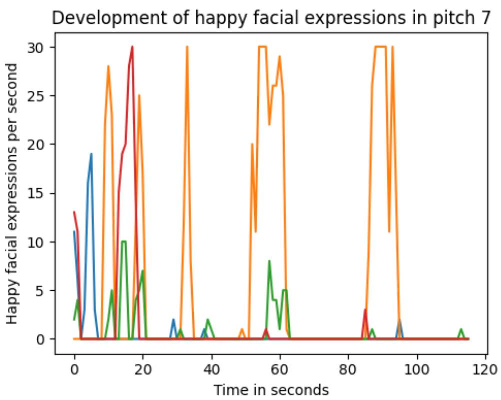

Development of happy facial expressions in pitch 2
Happy facial expressions per second
Time in seconds

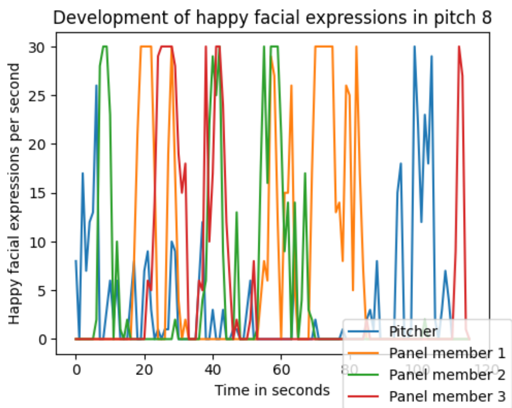

Development of happy facial expressions in pitch 3
Happy facial expressions per second
Time in seconds

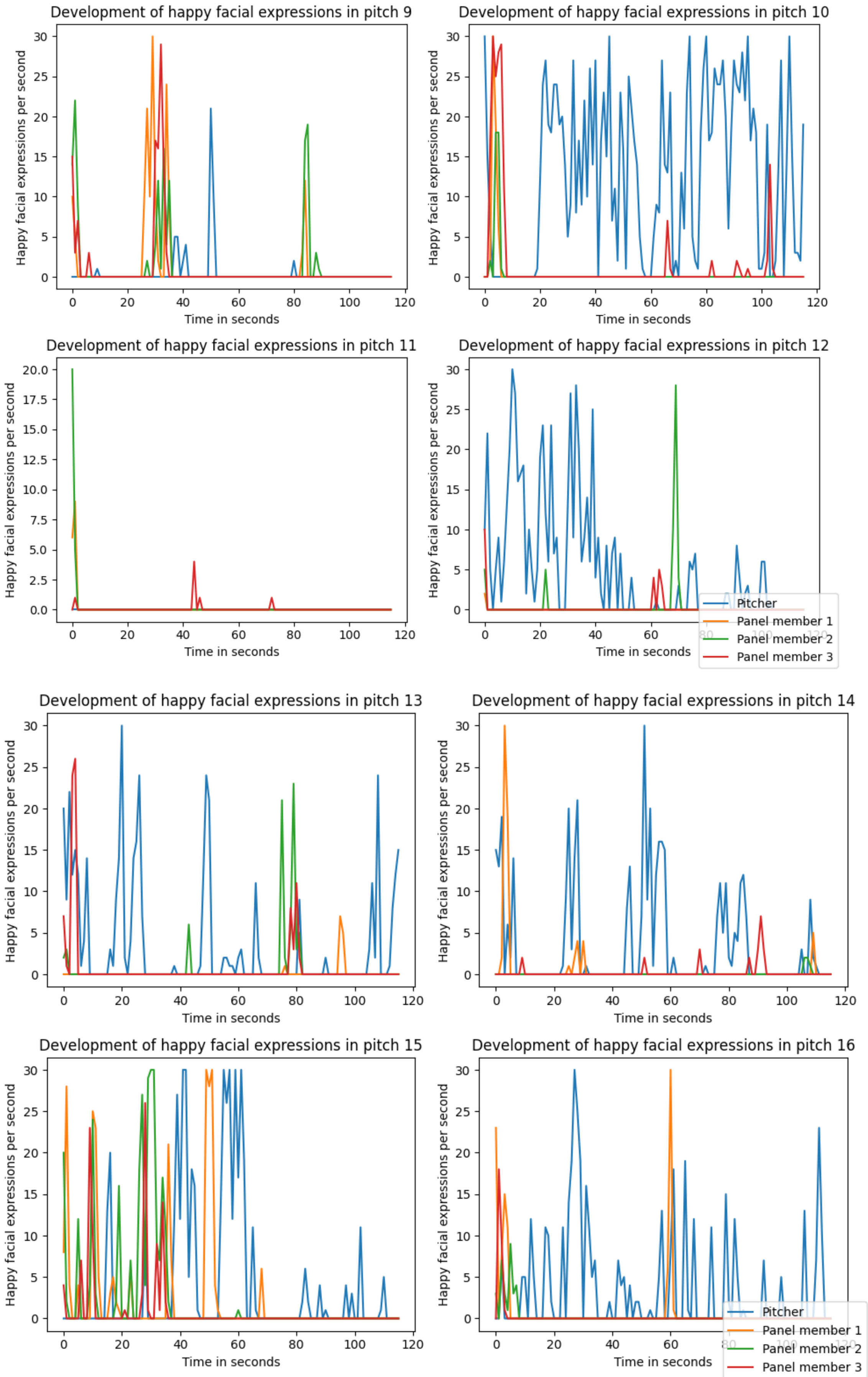

Development of happy facial expressions in pitch 4
Happy facial expressions per second
Time in seconds
Pitcher
Panel member 1
Panel member 2
Panel member 3

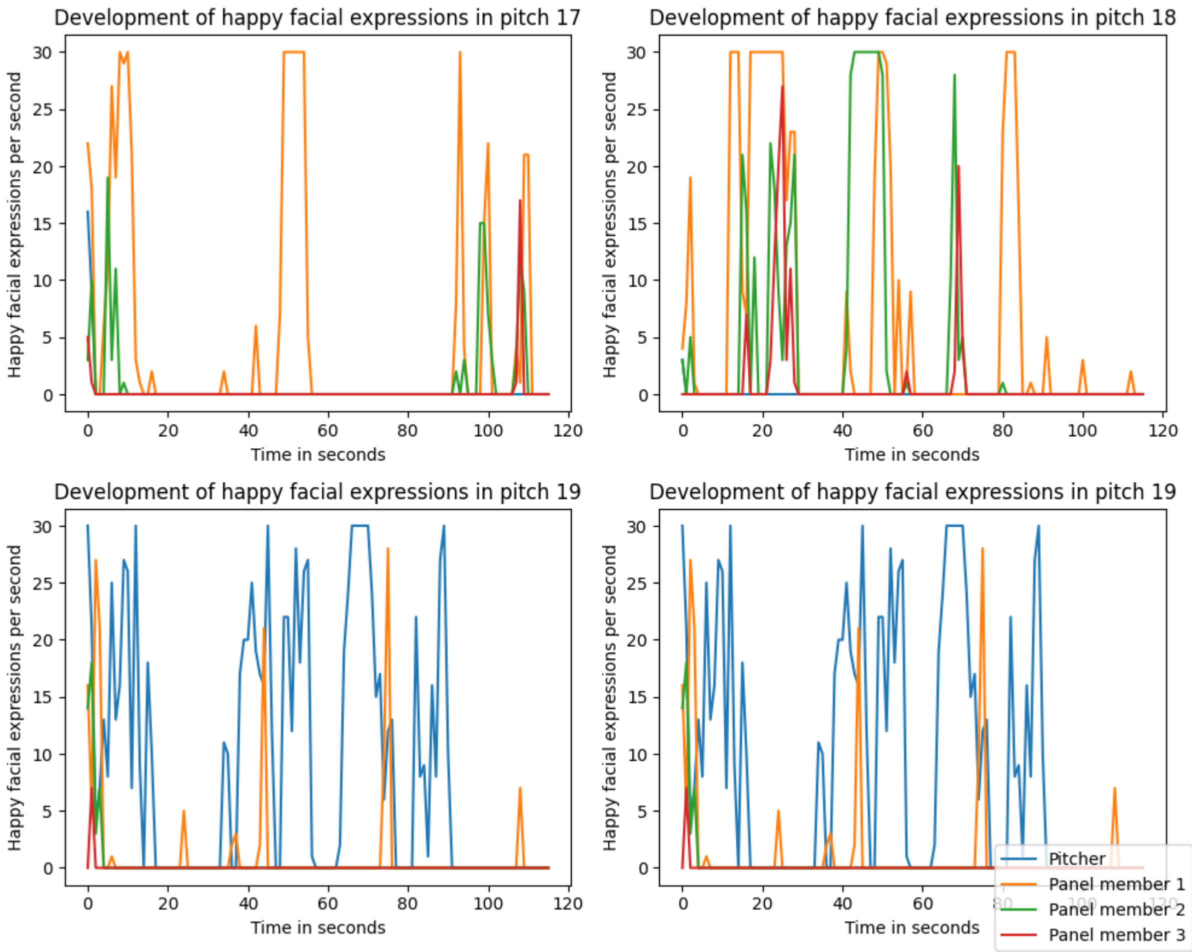

Development of happy facial expressions in pitch 5
Happy facial expressions per second
Time in seconds


Development of happy facial expressions in pitch 6
Happy facial expressions per second
Time in seconds


Development of happy facial expressions in pitch 7
Happy facial expressions per second
Time in seconds


Development of happy facial expressions in pitch 8
Happy facial expressions per second
Time in seconds
Pitcher
Panel member 1
Panel member 2
Panel member 3


Development of happy facial expressions in pitch 9
Development of happy facial expressions in pitch 10
Development of happy facial expressions in pitch 11
Development of happy facial expressions in pitch 12
Development of happy facial expressions in pitch 13
Development of happy facial expressions in pitch 14
Development of happy facial expressions in pitch 15
Development of happy facial expressions in pitch 16
Happy facial expressions per second
Time in seconds
Pitcher
Panel member 1
Panel member 2
Panel member 3


Development of happy facial expressions in pitch 17
Development of happy facial expressions in pitch 18
Development of happy facial expressions in pitch 19
Development of happy facial expressions in pitch 19
Happy facial expressions per second
Time in seconds
Pitcher
Panel member 1
Panel member 2
Panel member 3