Journal of Business Venturing 35 (2020) 105949

Contents lists available at ScienceDirect

Journal of Business Venturing

journal homepage: www.elsevier.com/locate/jbusvent

Founder passion, neural engagement and informal investor interest in startup pitches: An fMRI study☆

Scott Shane[a,*], Will Drover[b], David Clingingsmith[a], Moran Cerf[c]

[a] Case Western Reserve University, United States of America
[b] University of Oklahoma, 1003 Asp Ave, 3050J, Norman, OK 73019, United States of America
[c] Northwestern University, United States of America

ARTICLE INFO

Keywords:
Entrepreneurship
Cross-Brain Correlation (CBC)
Engagement
Investor decision making
Neuroscience
Venture finance

ABSTRACT

We explore how variation in entrepreneurs' displayed passion affects informal investor interest in start-up ventures by examining neural responses to entrepreneurs' pitches using functional Magnetic Resonance Imaging (fMRI). We find that founders displaying high passion increase investor neural engagement by 39% and investor interest in the venture by 26% over those displaying low passion. A one standard deviation increase in neural engagement is associated with an 8% percent increase in investors' interest in investing in a start-up company relative to the mean. Moreover, our findings indicate that neural engagement may account for some of the effect of founder passion on investor interest. Our study has implications for both research on, and the practice of, entrepreneurship.

1. Executive summary

Prior studies suggest that entrepreneurs who display higher passion are more likely to get investors to further investigate and fund their ventures (Cardon et al., 2017; Hsu et al., 2014; Landström and Mason, 2016; Mitteness et al., 2012; Sudek, 2006). Practitioners agree. Gasca (2014) explains, “As an observer, mentor and judge, I have seen numerous pitches fall flat because the entrepreneur failed to deliver even an ounce of passion through their pitch.”

The central aim of this study is to extend the literature on investor decision making and entrepeneur passion in three ways. First, we examine the effect of founder passion on the decision making of informal investors. While prior research has examined the effect of founder passion on the interest of venture capitalists and members of angel groups, none has examined the effect of founder passion on the interest of informal investors. Yet such informal investors are an important source of capital for early stage companies and account for the majority of start-up investment globally.

Second, we conduct a randomized experiment to test the passion effect. Cleanly manipulating and randomly assigning high and low passion pitch conditions allows us to show the *causal* effect of displayed passion on investor interest. Through this approach, we

---

☆ We appreciate the feedback from participants of the Stanford Interdisciplinary Symposium of Decision Neuroscience, the Babson College Entrepreneurship Research Conference, and the second workshop on Experimental Economics and Entrepreneurship. We also thank the following scholars who have provided valuable input on and/or assistance with various aspects of the paper: Tony Jack, Christopher Rose, Cameron Siler, Mark Sharfman, Danny Shoag, Adam Deurfeldt, and Matthew Wood. We thank the University of Oklahoma and Northwestern University for the funding and resources that made this study possible.

* Corresponding author.
E-mail addresses: sas46@case.edu (S. Shane), drover@ou.edu (W. Drover), david.clingingsmith@case.edu (D. Clingingsmith), moran@morancerf.com (M. Cerf).

https://doi.org/10.1016/j.jbusvent.2019.105949
Received 5 October 2018; Received in revised form 8 July 2019; Accepted 19 July 2019

provide evidence that displays of founder passion *cause* investor interest.

Third, leveraging tools from cognitive neuroscience, we develop and test a neural-based theory for *why* entrepreneur displayed passion may influence informal investor assessments. If passion is influential, then there should be measurable neural effects that can offer a biological explanation of why displayed founder passion matters. We theorize that displayed founder passion affects investor interest by enhancing neural engagement. Our theory is predicated on the idea that pitch delivery should cause investor brains to behave differently, such that high displays of passion recruits the brain in a way that increases fixation on the stimulus, which is the pitch. And because higher neural engagement increases focus and attention to the content and overrides distractions, we theorize that more engaged brains are more likely to meaningfully evaluate pitches, which should result in more favorable investor assessments. We argue that neural engagement partially mediates the displayed passion-investor interest relationship: Displays of passion trigger heightened engagement that, in turn, makes investors more likely to invest.

We find that randomly being assigned a pitch with high founder passion causes informal investor interest to increase by 26% relative to the null of low founder passion. We use functional Magnetic Resonance Imaging (fMRI) to examine investor neural responses to entrepreneurs' pitches. We find that higher founder passion increases investor neural engagement by 39% over lower founder passion. Finally, we find that a one standard deviation increase in neural engagement is associated with an 8% percent increase in investors' interest in investing in a start-up company relative to the mean. Our findings suggest that neural engagement could partially mediate the passion-investor interest relationship, but we cannot confirm it. The indirect effect is non-trivial in magnitude, but is not statistically significant.

The results of this study have several implications for the literature on venture financing and founder passion. Responding to growing calls for cross-discplinary research at the intersection of neuroscience and entrepreneurship (e.g., de Holan, 2014; de Holan and Couffe, 2017; McMullen et al., 2014; Nicolaou and Shane, 2014; Ward et al., 2017), our study shows how theories and techniques from neuroscience can be used to address previously unaddressed research questions about investor decision making. The result is a novel biological explantion for why displays of passion may be influential.

We also contribute to calls for experimental research in entrepreneurship (Hsu et al., 2017; Williams et al., 2019) by examining the causal effect of displayed founder passion through a randomized experiment. Doing so expands upon existing research by demonstrating the causal effect of displayed founder passion on investor interest. Further, we examine the decision making of informal investors, which has historically been overlooked by scholars.

Collectively, our findings provide evidence on neural responses to entrepreneur pitches and the role of displayed passion therein. We hope that our cross-disciplinary effort serves to motivate other scholars to further advance understandings of neural activity in entrepreneurship.

2. Introduction

Entrepreneurial passion — a founder's "demonstration of emotion, enthusiasm, and energy" (Pollack et al., 2012: 919) — is a key component of attracting institutional investor interest in new ventures. Entrepreneurs who appear passionate in their presentations are more likely to get investors to further investigate and fund their ventures, according to both practitioner observation and academic research (Bussgang, 2010; Cardon et al., 2017; Hsu et al., 2014; Landström and Mason, 2016; Li et al., 2017; Mitteness et al., 2012; Rose, 2008; Sudek, 2006).

While researchers have made considerable progress in understanding entrepreneurial passion, the literature is incomplete in three important ways. First, while prior research has examined the effect of founder passion on the interest of venture capitalists and members of angel groups, none has examined the effect of founder passion on the interest of informal investors—what the Global Entrepreneurship Monitor refers to as family, friends and foolhardy strangers. This omission is significant because informal investors account for the majority of startup investments, investing $1 trillion dollars globally over the period of 2012–2015 (GEM, 2016). Informal investors, then, represent an important group that is often neglected, both in venture financing research in general (Burke et al., 2014; Shane, 2008) and in studies of how passion influences investor decision making more specifically. We examine the effect of founder passion on the decision making of informal investors.

Second, our use of a randomized experiment also helps us to advance the passion-investor interest relationship. The gold standard for showing that one factor has a causal effect on another is a randomized experiment (e.g., Dimoka, 2011; Hsu et al., 2017; Williams et al., 2019). We add to the literature on founder passion and investor interest by using a randomized experiment in which displayed founder passion is manipulated via video pitches. This allows us to measure whether increased founder passion *causes* investor interest in funding new ventures to rise, or whether it's an artifact of something else.

Third, we break new ground by opening the black box of investor decision making, both theoretically and empirically, by studying the neural activity of informal investors as they are exposed to displays of founder passion. If passion is influential, then there should be measurable neural effects that can assist in explaining *why* displayed founder passion matters. Drawing on work from neuroscience, we theorize that displayed founder passion affects investor interest by enhancing neural engagement: *the extent to which an observer's brain becomes engrossed in a stimulus*. When neural engagement is higher, the brain is more fixated on the stimulus at hand (Barnett and Cerf, 2017; Dmochowski et al., 2012). Focus on and attention to content increases. We therefore theorize that more engaged brains are more likely to meaningfully evaluate pitches. The result should be a positive correlation between neural engagement and investor interest. Finally, we argue that neural engagement partially mediates the displayed passion-investor interest relationship. Displays of passion trigger heightened engagement that, in turn, makes investors more likely to invest.

We test our arguments by collecting neural data using functional Magnetic Resonance Imaging (fMRI) scans of informal investors' brains as they assess a randomly assigned set of entrepreneur pitch videos. Our results have several implications for research and practice. Specifically, we find empirically that founders' displayed passion causes investor interest. We also find that displayed passion causes an increase in investors' neural engagement, that neural engagement is associated with informal investor interest in financing new ventures, and that neural engagement may be a path through which entrepreneurs' displayed passion affects investors' interest. In short, our study contributes new insights to the lesser-studied group of informal investors, the role of displayed passion in venture financing, and advances the nascent intersection of neuro-entrepreneurship by offering a novel approach to studying investor decision making.

3. Passion and entrepreneurial pitches

Entrepreneurs must convince investors to provide financial support for their ideas (Chen et al., 2009; Drover et al., 2017; Huang and Pearce, 2015; Kerr et al., 2011; Robb and Robinson, 2014; Shane, 2008). Lacking established track records, early-stage entrepreneurs typically begin their approach with an initial elevator pitch (Chen et al., 2009; Kanze et al., 2018; Kerr et al., 2011). In practice, the most common investor response to an elevator pitch is to terminate investigation of a venture; only a minority of venture opportunities pitched capture interest and prove to be worth the cost of time to evaluate. The entrepreneur's goal with an elevator pitch, then, is to interest investors in conducting further investigation of the investment opportunity (Clingingsmith and Shane, 2018).

Within the pitch setting, researchers have argued that positive affect—particularly, passion—can play a key role in influencing funding assessments (Chen et al., 2009; Hsu et al., 2014; Mitteness et al., 2012; Murnieks et al., 2016). Passion may increase investor interest because it (1) enhances founder motivation (Chen et al., 2009), (2) boosts creative problem-solving (Cardon et al., 2013), (3) induces emotional contagion (Li et al., 2017); (4) influences tenacity (Cardon et al., 2009); (5) facilitates articulation of a vision (Chen et al., 2009); (6) boosts persuasiveness (Baron, 2008); and (7) increases effort (Drnovsek et al., 2016).

Despite the progress to date in understanding the role of passion in motivating investor interest, the literature remains incomplete in several ways. In Sections 3.1 through 3.3, we discuss three of these ways: 1) neglect of informal investors, 2) inconclusive evidence on causality, and 3) treating the brain as a black box.

3.1. Neglect of informal investors

Most studies explore how passion influences formal investors, such as venture capitalists and angel groups, and neglect *informal investors,* a large group that include ordinary individuals, such as friends and family members, as well as non-accredited investors (Bygrave et al., 2003). This is surprising given that informal investment is “the main source of external equity finance for business start-ups...” (Burke et al., 2014: 467), and that this group “has an enormous impact on overall entrepreneurial activity” (GEM, 2016: 45). For example, the amount of informal equity investment in early stage companies *exceeds* venture capital in both magnitude of dollars and investment (GEM, 2016; Burke et al., 2014; Lee and Persson, 2016; Robb and Robinson, 2014). Bygrave and Reynolds (2004) report that only 12% of the Inc. 500 fastest growing private companies in the United States received financing from business angels and < 2% received financing from venture capital firms. By contrast, one-third received financing from informal investors. An estimated 5% of the U.S. population is considered informal investors (GEM, 2016).

Venture financing research in general, and research on passion in particular, has paid scant attention to informal investors. Thus, by exploring the role of displayed passion in informal investment, we gain new insights on how passion influences the largest, yet presently overlooked group of investors.

3.2. Causality

While scholars have studied the passion-investor interest relationship, most work tends to be correlational in nature.[1] Previous researchers have shown a correlation between founder passion and the interest of institutional investors—venture capitalists and members of organized angel groups—and offer a variety of explanations for this correlation. However, the gold standard for showing that one factor has a causal effect on another is a randomized experiment (Williams et al., 2019; Hsu et al., 2017). Randomized experiments allow for the control of factors that likely confound observational data, such as inconsistencies in the way entrepreneurs exhibit passion, order effects, reverse causality, omitted variable bias, and reactions from other potential co-investors. For example, it is plausible that entrepreneur passion is related to the expected return from a venture, which may be apparent to investors but difficult for researchers to measure. The expected return is thus an omitted variable in correlational studies that leads to biased estimates of the effect of entrepreneur passion on investor interest.

To advance knowledge on this topic, we are getting inside the black box of passion. Prior research suggests that passion matters, but is less clear on why. Is it just that more passionate entrepreneurs have better ideas in a way we cannot measure but that investors

---

[1] Li et al. (2017) use an experimental design to show the effect of passion on the support of rewards-based crowdfunding. Rewards-based crowdfunding campaigns are very different from efforts to raise equity from investors. The median value that a person spends to support an equity crowdfunding campaign is approximately $100, while the median value of an angel investment is $10,000 and that of a venture capital firm in the millions of dollars (Shane, 2008). Moreover, the Securities and Exchange Commission does not consider rewards-based crowdfunding to be an investment and therefore regulates it differently from equity-based crowdfunding, such as Wefunder. While Li et al. (2017) provides fascinating results, we do not know if they apply to investing.

can detect? Or does passion affect them independently of the information conveyed about the venture?

Given these questions, an experimental design is the best way to measure the direct effect of passion. A small subset of the existing research has indeed made headway by examining the passion effect experimentally, yielding mixed results (e.g., Chen et al., 2009; Hsu et al., 2014; Li et al., 2017; Murnieks et al., 2016). However, this prior work has either manipulated entrepreneur passion via written text, limited the extent of randomization, examined decisions other than investing (such as rewards-based crowdfunding), and/or looked only at institutional investors. Thus, evidence on whether passion causes investor interest, either for informal or institutional investors, is not yet conclusive.

3.3. *Neural data*

Moreover, previous studies of investors' interest in startup companies tend to treat investors' brains as a black box. Despite neural-based explanations of behaviors in marketing, finance, economics and other related fields (e.g., Ariely and Berns, 2010; Glimcher and Fehr, 2013; Cerf et al., 2017), to date, no research has examined the neuroscience of responses to entrepreneurs' pitches. This means that researchers have overlooked neural-based explanations of why passion may play an influential role in shaping investor decision making. Testing this explanation requires information on investors' brain function, something that the typical social science research techniques of surveys, interviews and secondary data analyses cannot ascertain.

3.4. *Extending the entrepreneur passion-investor interest literature*

Our investigation begins to fill the voids outlined above. First, we study the effect of displayed passion on informal investors rather than formal investors. As noted, informal investors put billions into early stage companies each year. Thus, by exploring the role of displayed passion in informal investment, we gain new insights on how passion influences a large, yet presently overlooked, group of investors.

Next, we both complement and extend the literature on founder passion and investor interest by deploying a randomized experiment in which displays of founder passion in pitch videos are manipulated across concepts and entrepreneurs to help determine if founder passion *causes* investor interest, or if the observed correlation is an artifact of something else. While offering a more rigorous test, our approach builds on existing research, thereby serving as a pathway to forge new understandings of the role of passion, and whether it causes informal investor interest.

Finally, we open the black box of investor decision making by looking at how informal investors respond to founder displays of passion. We overcome this problem by collecting neural data from functional Magnetic Resonance Imaging (fMRI) scans of prospective investors' brains as they assess a randomly assigned set of entrepreneur pitch videos. Doing so, we argue that displayed founder passion affects investor interest by enhancing neural engagement: *the extent to which an observer's brain becomes engrossed in a stimulus*. Our approach, then, advances a neural-based theory of why and how displayed entrepreneur passion influences informal investors.

4. Hypothesis development

4.1. *Displayed entrepreneurial passion and neural engagement*

When investors view entrepreneur pitches, they attempt to decipher which opportunities merit further consideration. Investors then put time and money into further investigation of those opportunities that meet this initial screen. This sequential process means that, at the first stage of the process, entrepreneurs need to “get their foot in the door” by capturing initial investor interest. By eliciting a positive response from investors to their pitches, founders have the chance to eventually receive investment from those financiers (Petty and Gruber, 2011).

Communications researchers have found that the way information is delivered affects human reactions in a direct manner (DePaulo, 1992; Miller et al., 1976; Patrick et al., 2000). High-affect delivery, including spatial movement and extensive voice inflection, tends to be beneficial to getting recipient interest independent of the content that is being conveyed (Moè, 2016). If this is the case, then an experimental manipulation of an aspect of delivery is best suited to assess its effect.

Prior research on entrepreneurship argues that the display of affect plays an important role (Baron, 2008). Positive affect is persuasive (Hatfield et al., 1993), leading entrepreneurs displaying such emotions to be better able to generate positive responses from others (Baron, 2008; Cardon, 2008; Li et al., 2017). Because entrepreneurs must persuade others of the potential value of a new venture idea, positive affect might make investors more interested in providing resources to entrepreneurs.

Displayed entrepreneurial passion — a founder's display of positive emotion, enthusiasm, and energy is seen as an important aspect of positive affect (Mitteness et al., 2012). This displayed passion enhances persuasiveness (Baron, 2008). As Chen et al. (2009: 199) argue, “passion is often critical to convince the targeted individuals to invest their money, time, and effort in the new venture.”

Practitioners agree. Gasca (2014) explains, *“As an observer, mentor and judge, I have seen numerous pitches fall flat because the entrepreneur failed to deliver even an ounce of passion through their pitch.”* As another investor notes: *“If you're going to launch a startup, you had better be passionate about it. And you better be able to transmit that passion”* (Bussgang, 2010).

Entrepreneurs delivering pitches to raise capital vary in the degree to which they display passion (Li et al., 2017; Murnieks et al., 2016). An entrepreneur's passion thus may affect the investor's level of interest, and open or close the door to potential financing (Davis et al., 2017; Li et al., 2017; Warnick et al., 2018). Researchers have shown that investors such as venture capitalists and angel investors consider the passion of the entrepreneur to be an important characteristic in the investment decision (MacMillan et al., 1987; Mitteness et al., 2012). Studies have shown also that passion is correlated with entrepreneurs' ability to obtain resources from investors (Cardon et al., 2017; Davis et al., 2017; Mitteness et al., 2012; Sudek, 2006).

Displayed passion might enhance investor interest for a number of reasons, several of which have been articulated in the entrepreneurship literature. Founders may be more persuasive when they are more passionate about their ventures because they seem more confident. Confidence can be important given the uncertainty surrounding new ventures (Huang and Pearce, 2015; Zacharakis and Shepherd, 2001). Passionate founders may create emotional contagion (Cardon, 2008), where the founder's excitement spills over to the investors (Li et al., 2017). Entrepreneurial passion may signal the founder's commitment to the venture (Vallerand and Houlfort, 2003). A founder's passion may motivate him or her to work harder (Chen et al., 2009). Or it could be that passion is simply correlated with the expected return to the venture in a way investors can detect but for which a correlational study cannot adequately control.

While research on investor decision making hints at the process through which this might happen (Li et al., 2017; Mitteness et al., 2012; Pollack et al., 2012), to date researchers have yet to explore how responses to displayed entrepreneurial passion ultimately unfold in the investor's mind.

Cognitive neuroscientists have proposed a different mechanism for why displayed founder passion might enhance investor interest than that discussed in the entrepreneurship literature (Barnett and Cerf, 2017; Dmochowski et al., 2012; Hasson et al., 2004; Cerf et al., 2017; Mackay et al., 2012). These works suggest that displayed entrepreneurial passion might enhance neural engagement (Barnett and Cerf, 2017; Dmochowski et al., 2012; Poulsen et al., 2017). The cognitive effects of higher neural engagement are increased attention to the content at the expense of other stimuli (e.g., Barnett and Cerf, 2017; Dmochowski et al., 2012; Hasson et al., 2004). Regardless of whether a stimulus is a movie, piece of music, lecture, or an entrepreneur's pitch, higher engagement suggests that the observer's brain is undergoing a more powerful fixation on the stimulus, whereas lower engagement leaves the brain less fixated (Hasson et al., 2004; Schmälzle et al., 2015).

More passionate delivery of a message should focus the observer's mind on the presenter in a way that is more engrossing. Under such circumstances, other competing potential stimuli or distractions become less likely to override the recipient's focus and attention (Cerf et al., 2009). Prior research shows that neural engagement increases when listening to speeches of higher rhetorical quality (Schmälzle et al., 2015). Moreover, whole brain engagement increases during movie scenes characterized as more emotionally intense (Hasson et al., 2004). And when viewing more dynamic or emotional video clips, individuals experience moment-to-moment neural synchronization (Nummenmaa et al., 2012).

We hypothesize that these patterns are the same in the setting of entrepreneurs pitching investors as they are in other settings where variations in delivered content affects engagement. While several factors affect the degree to which an observer's brain becomes engaged in response to an entrepreneur's pitch, a key determinant is the nature of the pitch delivery. High versus low displays of passion should trigger measurable differences in the brain's level of engagement. This leads to our first hypothesis:

Hypothesis 1. Higher levels of displayed entrepreneur passion causes more investor neural engagement.

4.2. Investor neural engagement and investor interest

As we explained earlier, investors finance only some of the ventures pitched to them (Carpentier and Suret, 2015). Prior studies (e.g., Clingingsmith and Shane, 2018) show that this distribution means that the investor's default decision on any venture pitched is "no." Given a negative investors' default, pitching them involves a two-step process. First, founders must get investors to focus on an idea to evaluate it. Second, the idea must then be evaluated positively. Neural engagement is important for the first part.

To get investors to invest, founders must first get investors to connect with their message; individuals cannot evaluate positively that which does not first meaningfully engage their thinking. As explained above, neural engagement is the process by which the brain becomes engrossed in a stimulus.

Researchers have shown this concept in settings other than that of pitching investors, such as audience engagement in advertising and entertainment. Prior studies show that neural engagement plays a role in preference ratings. For instance, neural engagement is associated with popularity and viewership of television shows and commercials (Dmochowski et al., 2014). Other research links higher neural engagement to future memory of the content, liking of the content, and purchasing behavior at the individual and population level (Barnett et al., 2016; Barnett and Cerf, 2017; Dmochowski et al., 2012; Hasson et al., 2008).

To the extent that neural engagement mediates the investor's decision making, if the investor does not neurally engage with a founder's message, the outcome will be the investor's default decision, which is "no." As both the practitioner and research literature indicate, when people are not neurally engaged, their mental attention is diverted away from the presenter's message. Investors are frequently described as not focusing on pitches, attending to their phones, mind-wandering, or performing a host of other things that vie for their mental resources.

Indeed, practitioners observe this phenomenon frequently. One top venture capitalist explains, *"…even after getting in the room, many investors barely seemed to pay attention"* (Hilaly, 2019). Similarly, legendary investor Brad Feld, founder of Tech Stars and the Foundry group says, *"If you are an entrepreneur, you have less than 60 seconds to get an investor's attention"* (Clingingsmith and Shane, 2018: 5164).

Getting investors to become neurally engaged may therefore be crucial. If the investor is less engaged, the odds that the investor will hear the founder's message decrease, reducing the likelihood of a positive assessment. More passionate presenters get observers to more thoroughly connect with what they are presenting—acting as a concentrating function. If observers neurally engage with a founder's message, they can then evaluate it, rather than relying on the default decision. This, in many ways, is not different than what marketing experts deem being in the "consideration set." One wants to first get attention and then preference and then favorability (Milosavljevic and Cerf, 2008).

Being more neurally engaged does not guarantee that investors will invest. When investors are more engaged, and therefore more likely to hear the founder's message, they are more likely to give careful consideration of the information presented to them. That evaluation can be positive – *I want to gather more information* – or negative – *this is a definite "no."* Once engaged, investors might find a deal financially unappealing or may not believe that the venture has good odds of success. Because some portion of the time observers will evaluate information they receive positively, higher levels of neural engagement result in an association between presenter passion and investor interest.

We would not expect a perfect correlation between neural engagement and investor interest, but merely a positive one. The absence of neural engagement would result in zero investor interest. Higher levels of neural engagement would result in investor interest in some cases, resulting in a positive correlation of less than one between investor neural engagement and investor interest. This argument leads to the second hypothesis:

Hypothesis 2. Higher investor neural engagement during the exposure to a pitch is positively associated with investor interest.

4.3. Displayed entrepreneurial passion and investor interest

Previous researchers have explored whether entrepreneur passion can affect the interest of investors in financing new businesses. While this area of research is "in its infancy and little is known about whether the relationship exists in the first place…" (Mitteness et al., 2012: 592), several observational studies have demonstrated a correlation between founder passion and investor interest (Cardon et al., 2017; Mitteness et al., 2012; Sudek, 2006).

This correlation suggests that founder passion might enhance investor interest. But these associations are not universally accepted. Other works have shown that there is no association between certain types of founder passion and investor interest (e.g., Chen et al., 2009).

It is tricky to infer from correlational research that there is a causal relationship between founder passion and investor interest. The correlations shown in previous works could be artifacts of unobserved heterogeneity, selection, or omitted variable bias. They could also be due to reverse causality. Human beings display emotion that responds to the behavior of others (Hatfield et al., 1993). For instance, when people frighten others, those others often get upset. Such reverse causality is also possible with investor interest and founder passion: When investors display interest in ventures, entrepreneurs may display more passion about their ventures. An advantage of the use of an experimental design to examine this question is that, if pitches are pre-recorded, there cannot be feedback from investor affect to the performance of the founder. Most prior research on this question has not used controlled videos and/or are limited in the extent of randomization (e.g., Chen et al., 2009; Hsu et al., 2014; Murnieks et al., 2016). Experimental results have been mixed—some suggesting passion influences investors, while others suggest otherwise. The causal influence of passion is not conclusive.

Our arguments, like that of previous researchers, would suggest that the statistical association between founder passion and investor interest seen in correlations is neither the result of reverse causality, nor an artifact of unobserved heterogeneity, selection or omitted variable bias. Therefore, we expect that founder passion *causes* greater investor interest.

Hypothesis 3. Higher levels of displayed entrepreneur passion cause more investor interest.

4.4. Investor neural engagement partially mediates the entrepreneur passion-investor interest relationship

We argue that investor neural engagement partially mediates the relationship between entrepreneurs' displayed passion and investor interest. While there may be other mechanisms through which an entrepreneur's passion might affect the level of investor interest, the neuroscience literature suggests one of those mechanisms is neural engagement. As we have argued, displays of passion trigger heightened engagement that, in turn, makes investors more likely to invest.

We do not believe that neural engagement would be more than a partial mediator of the relationship between displayed passion and investor interest. Human beings are too complex biologically for there to be a single mechanism through which the display of passion could affect something as multifaceted as the interest of investors in financing a company. This is reflected in the number of plausible alternative paths through which founder passion could affect investor interest proposed in the entrepreneurship literature. These include founder motivation (Chen et al., 2009), creative problem-solving (Cardon et al., 2013), tenacity (Cardon et al., 2009), articulation of a vision (Chen et al., 2009), persuasiveness (Baron, 2008), effort (Drnovsek et al., 2016; Mueller et al., 2017) or through emotional contagion (Li et al., 2017). It is unlikely that only one path would explain passion to the exclusion of all others.

These other mediators could very well be uncorrelated with investor neural engagement because they would act on investors in unrelated ways. For instance, many of these potential other mediators, such as tenacity, or effort, influence founder behavior in ways that lead them to perceive that entrepreneurs are behaving in ways more consistent with their priors for founder type, thereby increasing investor interest.[2] Alternatively, displayed founder passion could lead to emotional contagion and influence investor interest by affecting the behavior of other investors, which the focal investors emulate. This argument leads to the fourth hypothesis:

Hypothesis 4. Higher investor neural engagement during the exposure to a pitch partially mediates the effect of displayed entrepreneurial passion on investor interest.

5. Methods

We manipulated displayed founder passion in pitches to investors in a randomized controlled trial and looked at the effect of variation in founder passion on the response of investors. We utilized brain imaging as subjects assessed a series of pitch videos to investigate the role of neural engagement in pitch assessments as well as their reported interest in investing in the ventures.

5.1. Subjects

Investors in early stage companies include institutional investors, such as venture capital firms and angel groups, and informal investors, such as friends, family and "foolhardy strangers." Almost all previous studies of the relationship between entrepreneur passion and investor interest have focused on institutional investors. Our study focuses instead on the informal investor subgroup.

Bygrave and Reynolds (2004:103) defined informal investors as "all men and women who had personally invested in a business startup that was not their own, excluding stocks and mutual funds." Informal investors therefore exclude venture capital firms and angel groups. Members of the latter entities do not invest "personally." Rather, the legal entity of the fund invests.

Informal investors are thus composed of friends and family of the entrepreneur as well as strangers who invest. We can identify no previous studies that have gathered data on the effect of entrepreneur passion on informal investor interest. Most of the studies on the topic of founder passion and investor interest have focused on venture capital firms and angel groups (Cardon et al., 2017; Chen et al., 2009; Hsu et al., 2014; Mitteness et al., 2012; Murnieks et al., 2016; Sudek, 2006). No studies to have looked at the relationship between founder passion and investor interest among informal investors.[3]

Informal investors are a large and heterogeneous group, comprising an estimated 5% of the population in the United States (GEM, 2016). While a typical neuroscience sample is too small to truly demonstrate its representativeness, our subjects do look similar to those who invest as informal investors. For instance, our sample roughly aligns with large sample surveys on the demographics of informal investors in the U.S. in terms of gender, age and education (Burke et al., 2014; GEM, 2016). The majority of informal investors in the U.S. are male (72%) (GEM, 2016), which aligns with our sample comprised of 67% males. In terms of age, 26% of informal investors globally are between 18 and 34, 50% are between 35 and 54, while 24% are between 55 and 65+ (Burke et al., 2011). In our sample, 10 subjects fall into the first category, while 5 fall into the second category. With respect to education, informal investors are relatively evenly distributed across 'no/low education' (30%), 'medium education' (32%) and 'high education' (38%) (Burke et al., 2011). Our sample maps onto this pattern as well, skewing toward higher levels of education (4 subjects, 11 subjects, in the latter two respective categories). More informally, we recruited our sample within an affluent community, where the median household income is nearly twice the US median. Individuals from wealthier households are more likely to be informal investors (Burke et al., 2014).

We recruited nineteen subjects to participate in our study. Four were screened out due to claustrophobia, corrupted scans, or excessive fidgeting, leaving fifteen subjects. Subjects were healthy, fluent English speakers with self-reported normal or corrected-to-normal vision. Subjects had the following characteristics 10 were males; males' mean age = 29.6, standard deviation = 6.85; females' mean age = 29, standard deviation = 8.46; average work experience = 6.4 years, standard deviation = 5.39; highest education: high school = 13%, some college = 13%, Bachelor's degree = 40%, Master's degree = 27%, doctorate = 7%. Subjects were not professional investors. All subjects were right-handed. Subjects provided written informed consent prior to the experiment. Five additional subjects which we originally used for pilot and calibration of the parameters were not used in analyses.

The ultimate use of fifteen subjects is in line with previous works using fMRI to look at cross-brain correlation (Hasson et al., 2004, 2008; Nummenmaa et al., 2012). As Laureiro-Martinez et al. (2015:325) note: "…a typical study averages 15 participants…[in cognitive neuroscience]." Moreover, our analysis increases the robustness and power by looking at the average of pairs of subjects rather than merely each subject compared to the average of all others. Thus, whereas the majority of fMRI studies draw the significance from the number of subjects, *n*, that share a similar effect, our cross-brain-correlation approach measures the alignment between pairs of subjects and the average of the pairwise comparisons, thereby yielding a set of $\frac{n(n-1)}{2}$ observations for n subjects.

---

[2] Consider the example of founder effort. Let P be passion, E be engagement, Y be interest, and X be the alternative mediator, such as exerting more effort. The model for this would be: $Y = \beta_0 + \beta_1 E + \beta_2 X + \beta_3 P + \varepsilon_1$, $E = \alpha_0 + \alpha_1 P + \varepsilon_2$, and $X = \gamma_0 + \gamma_1 P + \varepsilon_3$. In this example, passion makes people believe that the level of the alternative mediator is higher, e.g. that founders are exerting more effort, which increases their interest, making *perception* of founder effort an alternative mediator to neural engagement.

[3] We did identify one study of founder passion and investor interest that may have looked at accredited angel investors who were not a part of an angel group (Warnick et al., 2018). We believe that the sample in this study differs substantially from informal investors in general. Shane (2008) found that only 8% of informal investors were business angels. Of the business angels, he found that only 28% were accredited investors; only 2.2% of informal investments were made by accredited angel investors. Thus, most informal investors look like regular people. The Warnick et al. (2018) sample, then, is not one of informal investors.

5.2. Protocol and stimuli

Subjects were asked to view entrepreneur pitch videos while undergoing fMRI scanning. After initial briefing on the nature of the fMRI and the setting, we had subjects lie down in the scanner. Subjects wore fMRI-compatible headphones with noise cancellation (Universal Medical, Walpole, MA) to assure that the auditory experience was optimal. The headphones provided the same audio input to each ear.

We adopted a single factor 2-level design to manipulate founder passion. Following Mitteness et al. (2012), we distinguish between different types of passion: felt, displayed and perceived. Felt passion is passion experienced by an entrepreneur; displayed passion concerns the appearance of passion, such as "appearing enthusiastic in their presentations" (Mitteness et al., 2012: 593); perceived passion pertains to how passionate external observers think an individual is. We focus on displayed passion.

To create the pitch videos, we recruited ten actors and had them deliver pitches in front of a camera. The concepts delivered were based on actual early-stage pitches drawn from online fundraising platforms. For instance, one concept was an enterprise collaboration tool, another was a platform for finding and hiring attorneys, while a third was a 3D printing-based concept. Each actor delivered their unique pitch script twice: once with high passion and once with low passion. These made the stimuli in each group high/low passion.

We operationalized displayed passion as high enthusiasm, in alignment with prior research that indicates that investors' enthusiasm is a key driver of displayed passion (Li et al., 2017; Mitteness et al., 2012). Presenters were coached to manipulate their delivery along the dimensions shown to correlate with enthusiasm, namely energy level, voice tone, spatial movement, and facial expressions (see Broekens et al., 2012; Patrick et al., 2000; Watson et al., 1988 for elaboration). The presenting entrepreneur in each video occupied the same visual angle on the screen, with the same background and similar content properties (clothes, manner of speech, etc.). These elevator pitches lasted an average of one minute. Fig. 1 offers an overview of the design and approach.

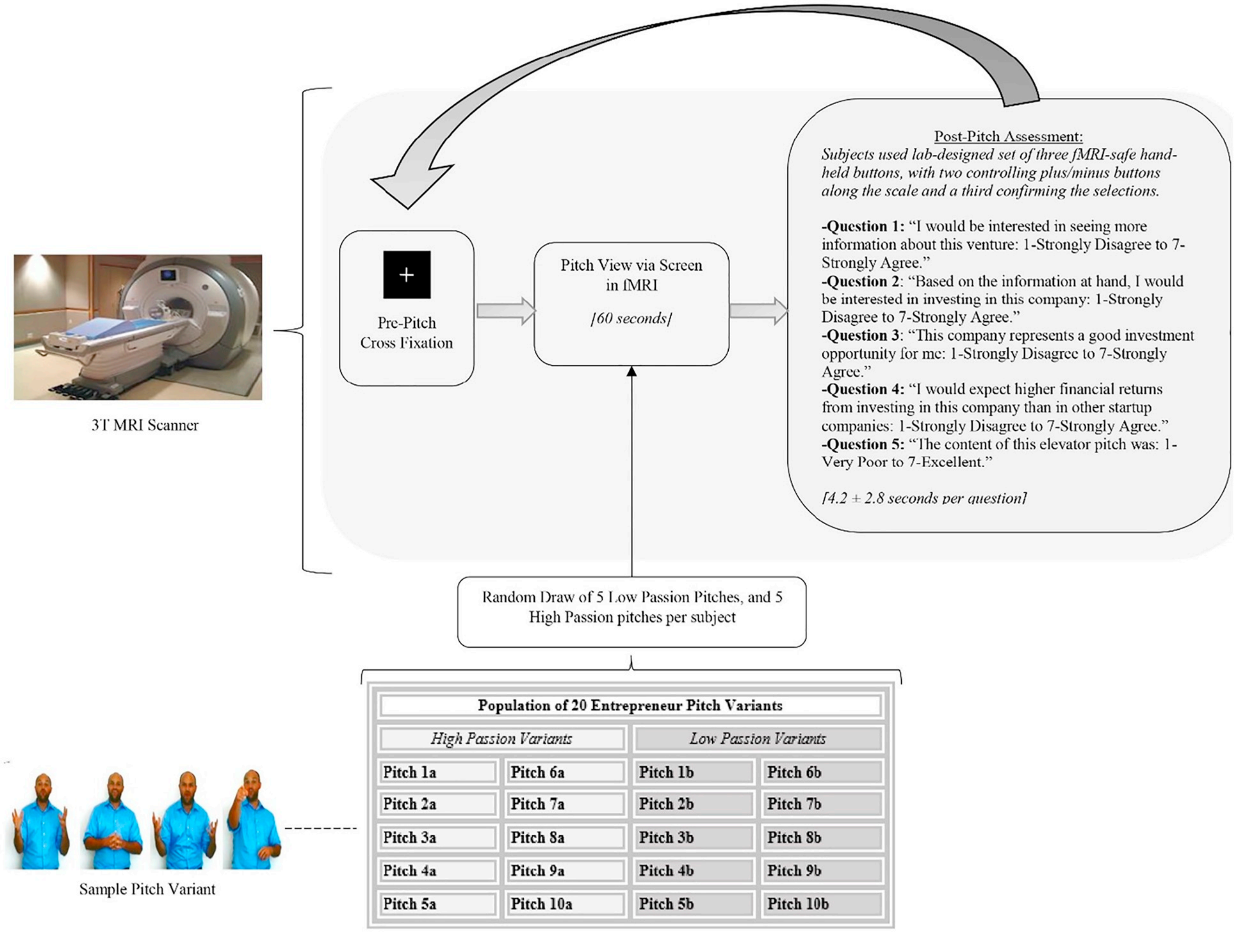
To ensure that each high/low passion pitch indeed reflects the attributes assigned, we had independent coders rate the pitches. First, thirty individuals rated the pitches to assess the level of displayed enthusiasm. Questions included: a) "The voice inflection of the entrepreneur in the video is considered: 1-Low Inflection to 7-High Inflection; b) The spatial movement of the entrepreneur, particularly with regard to the use of hand gestures in this video is considered: 1-minimal movement to 7-extensive movement; c) The positive facial expressions of the entrepreneur, particularly with regard to smiling, are considered: 1-no facial expressions to 7-extenstive facial expressions; and d) Overall, please rate the degree of enthusiasm that the entrepreneur displayed throughout the pitch: 1-low enthusiasm to 7-high enthusiasm." Means across all questions were 1.56 for the low conditions and 5.6 for the high conditions. The means were significantly different ($p < 0.05$, t-test). Second, we had another set of 28 coders rate the pitches on Li et al.'s (2017) scale of displayed passion, which includes: "The project team/creator: (a) appear(s) excited about the project idea; (b) convey(s) an obsession about the project idea; (c) appear(s) enthusiastic about the project idea; (d) is able to convey(s) his or her enthusiasm for the project idea; (e) appear(s) to be passionate about the project idea; and (f) display(s) an urge to complete the project." Raters were asked the extent to which they agree with each on a scale of 1–5. Means across all questions were 1.62 for the low conditions and 4.02 for the high conditions. The means were significantly different ($p < 0.05$, t-test). This data suggests that our efforts to manipulate displayed passion were effective.

In the neural study, we randomly assigned each subject to view ten out of the pool of twenty possible pitches, resulting in 147 pitch assessments (removing the ones with corrupted or missing data as mentioned in the 'Subjects' section above, plus an additional three clips with missing data). Pitches were viewed through a monitor visible inside the fMRI scanner using a mirror that reflected a screen outside the scanner. Each subject viewed each entrepreneur/concept only once. Each subject viewed five high-passion and five low-passion clips. The ten clips viewed by each subject were shown in random order such that the high/low passion clips were intermixed. The order of the clips was also randomized within a condition such that one subject may have seen her first clip as clip #7 (high-passion) whereas another may have seen first clip #10 (low-passion). Each clip was therefore viewed by at least five subjects and up to ten subjects. Together, our approach enables us to investigate subjects' neural responses to high- and low-passion pitches that occur across a set of randomly assigned entrepreneurial concepts, pitched by different entrepreneurs. Content viewing did not require head motion or notable eye movement.

After viewing each pitch video, subjects were prompted with a set of questions that captured investment interest. Question 1: "I would be interested in seeing more information about this venture: 1-Strongly Disagree to 7-Strongly Agree." Question 2: "Based on the information at hand, I would be interested in investing in this company: 1-Strongly Disagree to 7-Strongly Agree." Question 3: "This company represents a good investment opportunity for me: 1-Strongly Disagree to 7-Strongly Agree." Question 4: "I would expect higher financial returns from investing in this company than in other startup companies: 1-Strongly Disagree to 7-Strongly Agree." Question 5: "The content of this elevator pitch was: 1-Very Poor to 7-Excellent." Items were averaged to form a scale of investor interest. The investor interest scale revealed a Cronbach's Alpha of 0.92, indicating high internal consistency across items.

Reponses were controlled using a lab-designed set of three fMRI-safe hand-held buttons, with two controlling plus/minus along the scale and a third confirming the selections. We placed no time limit on the responses and subjects generally responded to each question in a matter of a few seconds (4.2 ± 2.8 s).

The stimuli were controlled using an experimental software: *Presentation* (Neurobehavioral Systems, Berkeley, CA). Following the videos, subjects were debriefed on their experience. This was done mainly to monitor for potential tiredness or lapses of attention or to identify any potential flaw in the experiment. No subject reported any such problems.



Post-Pitch Assessment:
Subjects used lab-designed set of three fMRI-safe hand-held buttons, with two controlling plus/minus buttons along the scale and a third confirming the selections.

-**Question 1:** "I would be interested in seeing more information about this venture: 1-Strongly Disagree to 7-Strongly Agree."
-**Question 2**: "Based on the information at hand, I would be interested in investing in this company: 1-Strongly Disagree to 7-Strongly Agree."
-**Question 3**: "This company represents a good investment opportunity for me: 1-Strongly Disagree to 7-Strongly Agree."
-**Question 4:** "I would expect higher financial returns from investing in this company than in other startup companies: 1-Strongly Disagree to 7-Strongly Agree."
-**Question 5:** "The content of this elevator pitch was: 1-Very Poor to 7-Excellent."

[4.2 ± 2.8 seconds per question]

Population of 20 Entrepreneur Pitch Variants

High Passion Variants		*Low Passion Variants*	
Pitch 1a	**Pitch 6a**	**Pitch 1b**	**Pitch 6b**
Pitch 2a	**Pitch 7a**	**Pitch 2b**	**Pitch 7b**
Pitch 3a	**Pitch 8a**	**Pitch 3b**	**Pitch 8b**
Pitch 4a	**Pitch 9a**	**Pitch 4b**	**Pitch 9b**
Pitch 5a	**Pitch 10a**	**Pitch 5b**	**Pitch 10b**

Fig. 1. fMRI experimental design.

5.3. fMRI

Subjects' fMRI data were acquired using a 3T MRI scanner (Skyra, Siemmens) with a standard head coil. Functional scans were acquired using an echo planer imaging (EPI) sequence. Time to Repetition (TR) was 2000 ms; Time to Echo (TE) was 20 ms. Each volume comprised of 38 slices of 3 mm thickness. Anatomical images were acquired using a T1-weighted pulse sequence (TR, 2300 ms; TE, 3.08 ms; FOV, 220 mm^2).

Simply put, the fMRI acquires a full reading of a subject's brain every two seconds (0.5 Hz). The reading incorporates the overall BOLD signal which reflects the amount of 'energy'[4] the specific brain area (termed: Voxel for 'VOlume piXEL') required in the time window. Since the brain typically registers activity in much faster speeds (in the order of milliseconds) this reflects the energy required by hundreds of thousands to millions of brain cells in the window of time. This energy does not map directly to neural response but acts as a proxy for the brain activity that a specific site reflects in a given task (Heeger and Ress, 2002).

To minimize head movement, subjects' heads were stabilized with foam padding. fMRI data were reconstructed using BrainVoyager QX (Brain Innovation) and analyzed using Matlab (MathWorks, Natick, MA). Functional scans were 3D-motion-corrected. The functional dataset was transformed to a 3D Talairach space (Talairach and Tournoux, 1988) and projected on a reconstruction of the cortical surface.

To diminish the impact of global, non-neural signal artifact on local BOLD signals, we projected-out the mean white matter signal from the BOLD signal in each voxel in each subject. The mean signal was calculated individually for each subject and was entered into a linear regression to predict the BOLD signal in each voxel. The BOLD signals were then replaced with the residuals resulting from this regression, and the mean and variance of each of these residuals were matched to the mean and variance of the pre-projection BOLD signal. Raw voxel data from the fMRI was normalized onto a scale of 0 to 1 over the course of the recording period.

5.4. Cross-brain correlation

Capturing the level of engagement in content has historically been challenging. Post-hoc self-reports about an experience may suffer from recency bias, whereas questioning the respondents *during* the experience can lead to detachment from the experience (Boksem and Smidts, 2015). Tools such as eye tracking may not fully capture what is transpiring in the mind, and numerous real-time measures (i.e., dials used by pollsters or marketing researchers) often influence the engagement by making subjects fail to immerse themselves in the experience. As such, tools from neuroscience offer an important and better avenue for capturing engagement (Hsu, 2017).

Researchers can use neural imaging to measure engagement through correlating neural activations across multiple brains when exposing subjects to the same content (Barnett and Cerf, 2017; Dmochowski et al., 2012, 2014; Hasson et al., 2004; Lankinen et al., 2014; Schmälzle et al., 2015). Neuroscientists generally believe that inter-subject correlations are a good metric for measuring engagement (Dmochowski et al., 2012). That is, regardless of the site and functions in the brain that drive engagement, multiple brains that are experiencing the same engaging content should reflect a consistent, correlated dynamic response across all brains.

Engaging content, such as a tense movie plot or an elegant speech, drives the brains of different people to function in a similar fashion — the content impacts those brains in a way that 'overrides' their idiosyncratic preferences (Schmälzle et al., 2015; Hasson et al., 2004; Nummenmaa et al., 2012). As Schmalze et al. (2015:1137) note: *"during powerful speeches, listeners as a group are more coupled to each other, suggesting that powerful speeches are more potent in taking control of the listeners' brain responses."*

This engagement can be computed by averaging the whole-brain activity of multiple individuals after aligning the responses temporally (all subjects viewing times are the same, and they are matched second-by-second) and spatially (all brains are co-registered such that responses in neural sites that are correlated suggest similar sources). This metric yields a measure in which higher correlation is indicative of high engagement and lower correlation suggests lower engagement. Put differently, the more correlated the neural activity across individuals (whole-brain), the more engaging the content; the less correlated the neural activity across brains, the less engaging the content.

To evaluate momentary engagement from the neural data, we compared the aligned brains of subjects across 111 Regions of Interest (ROIs) selected based on the Harvard-Oxford atlas. Each ROI is comprised of voxels that are implicated together with specific brain function or structural entity (e.g. 'amygdala', or 'frontal lobe'). These voxels were aggregated into the designated ROIs and averaged to generate a single time-series value for activity at each ROI location over the course of the recording period. For each pair of subjects who were randomly assigned to the same pitch, pairwise correlations of ROI activity were taken across all ROIs at each time frame, and the results were averaged across all pairs to generate a Cross Brain Correlation (CBC) time-series of similar neural activity over the course of each pitch video (see also Appendix Table 3 for analysis of the CBC within each ROI).

While CBC is typically calculated for an average of all pairs, here we were interested in engagement at the individual level. Thus, to test our hypotheses, we computed the CBC for an individual subject. As CBC is a comparison *between* subjects, we calculated the individual contribution by only calculating the pairwise correlation of a single subject and all others. That is, if the CBC focused on subject 4, we computed the pairwise neural correlation between this subject and all others in the group (e.g., 4–1, 4–2, 4–3…4-n). For the individual engagement CBC analysis, we averaged the neural responses across all the time-series of all subjects with the individual

---

[4] BOLD (Blood-oxygen-level dependent imaging) is a measure of blood flow, which is a proxy to the metabolic activity in a brain region, which in turn correlates with neural activity. However, the connection between neural activity and increase/decrease in BOLD signal is indirect and is a subject for large body of research (see Singh, 2012 for more details).

subject we were investigating, and then compared the response in each ROI. The result is a measure of *individual engagement* for each pitch view that ranges from 0 (low individual engagement) to 1 (high individual engagement). This score was normalized to a 0–100 scale during the statistical analysis for more intuitive unit interpretations. The brains of two individuals who are not at all aligned (i.e. two people doing completely different tasks) should be closer to 0. To our knowledge, boundaries or thresholds for what constitutes 'high' or 'low' engagement are not widely established in neuroscience, as most studies examine within-experiment fluctuations and their resultant influence. To explain the inter-subject calculation in greater detail, see Appendix Fig. 1, Hasson et al. (2004), Barnett and Cerf (2017) and Dmochowski et al. (2012).

6. Analysis and results

The experiment exposed each of fifteen subjects j to ten different ventures k. For each viewing i, we randomly determined whether a high-passion or low-passion variant of a pitch for the venture would be shown. Let p_i be an indicator variable for whether viewing i featured a high passion variant. Our outcomes y_i are the investor interest scores subjects gave to each viewed pitch and the measure of neural engagement we computed during that viewing. We are primarily interested in the effect of passion β in the regression model:

$$y_i = \alpha + \beta p_i + \varepsilon_i,$$

where ε_i is an error term. Since our experiment included variation at both the subject and venture level, we use multilevel modelling in the analysis. The subject and venture levels are not nested. We consider variants of the model where 1) the intercept α and coefficient β are modelled as random variables at either the subject level, venture level or both. In these variants, we label the random intercepts α_j and δ_k and the random coefficients β_j and β_k.

Ventures differ in the quality of ideas and subjects differ in their baseline interest in investment, which justifies the inclusion of the random intercepts. We are primarily interested in the average effect of passion, not in estimating the effects for individual subject and ventures, which argues for treating β as fixed rather than random. Nevertheless, we estimate models of increasing complexity and compare their efficiency in use of the data using the Akaike Information Criterion (AIC). We examine the AIC rather than the likelihood ratio because the models are not nested. Estimation is conducted using the STATA program `mixed`.

Appendix Table 1 shows six models with investor interest as the dependent variable. The first column shows an estimation with a fixed intercept and coefficient of interest. Columns 2 and 3 allow for random intercepts by subject and venture, while column 4 includes both random intercepts. The model in column 4 has the lowest AIC, suggesting it makes the most efficient use of the data. It is also our preferred specification given the data generating process and the goals of the estimation. Columns 5 and 6 include both the random intercepts and also allows the coefficient on passion to be random at the subject and venture levels, respectively. These specifications do not change the estimate on our coefficient of interest and make slightly less effective use of the data. Therefore, our preferred specification in modelling the effect of passion on investor interest includes random effects for both subject and venture.

Appendix Table 2 repeats the model selection exercise with individual engagement as the dependent variable. As columns 2 through 4 show, random intercepts for subject and video do not explain any of the variation in individual engagement and worsen the efficiency of the estimation relative to column 1 as shown by the increasing AIC.

Table 1 shows summary statistics of the main variables used in our analysis along with a correlation matrix.

In Hypothesis 1, we theorized that higher levels of displayed entrepreneur passion will lead to higher neural engagement. Our analysis shows that neural engagement is significantly different across manipulated conditions in the theorized direction. As Table 2 depicts, high versus low levels of displayed entrepreneurial passion during a pitch leads to higher levels of investor neural engagement ($B = 6.810$, $p < 0.001$), increasing engagement by 39% relative to its average level of 17.4 in the low passion treatment. Fig. 2 illustrates the correlation among subject's brains in the high and low passion conditions.

Hypothesis 2 argued that higher neural engagement would lead to higher investment interest. Table 3 shows the relationship between neural engagement and investor interest. In regressions that allow for subject and clip-level random effects, higher engagement is positively correlated with investor interest, ($B = 0.0553$, $p < 0.01$), such that a one standard deviation increase in neural engagement is associated with an 8% percent increase in investors' interest relative to the mean. The patterns are consistent if we disaggregate our investor interest scale and look at the effect of investor neural engagement on individual items measuring investor interest.

In Hypothesis 3, we argued that higher levels of displayed entrepreneurial passion would lead to higher levels of investor interest.

Table 1
Descriptive statistics and correlations.

Variable		Mean	Std. Dev.	1	2	3	4	5	6	7
1	Passion	0.50	0.50							
2	Engagement	20.83	5.62	0.61**						
3	Inv. Interest: Q1	4.11	1.72	0.24**	0.18*					
4	Q2	3.53	1.77	0.19*	0.14	0.79**				
5	Q3	3.68	1.77	0.21*	0.16	0.78**	0.87**			
6	Q4	3.56	1.64	0.18*	0.17*	0.63**	0.71**	0.79**		
7	Q5	4.03	1.64	0.31**	0.20*	0.63**	0.59**	0.61**	0.57**	
8	Inv. Interest Scale	3.78	1.49	0.26**	0.19*	0.88**	0.91**	0.93**	0.85**	0.78**

Table 2
Causal effect of passion on neural engagement.

	Neural engagement
Passion	6.810***
	(0.734)
Constant	17.40***
	(0.521)
Var(ε_i)	19.79***
	(1.154)
N	147

Standard errors in parentheses $^{+} < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

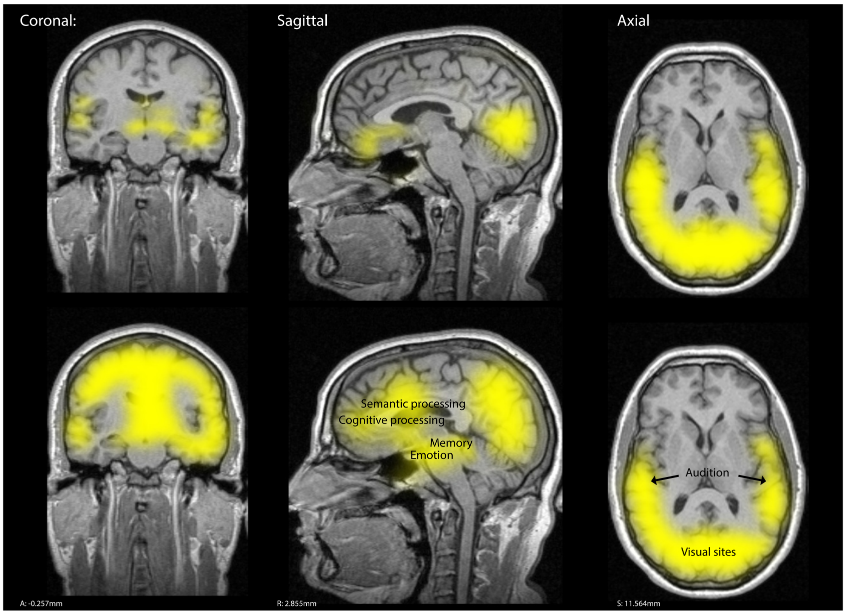


Fig. 2. fMRI activation map reflecting the areas consistently showing correlation across subjects in low-passion pitch (top row) and high-passion pitches (bottom row) *.

*An illustration of the areas showing high correlation (depicted in yellow) across multiple subject viewing low (top row) and high (bottom) passion pitch. Areas depicted in yellow in the Coronal, Sagittal and Axial views of the brain correspond to voxels that show activation across multiple viewers when a clip is shown. We highlight in the bottom panel some notable functions that are activated by the high-passion pitch (visual, auditory, semantic processing, emotion, and memory sites as well as cognitive processing of the content). Those sites were shown in previous works to be part of a highly engaging content (see Hasson et al., 2008; Barnett and Cerf, 2017). The top row reflects a set of sites that are activated during low-passion pitch – primarily pertaining to the visual/auditory processing of the content.

We examined the effect of the randomized treatment of entrepreneurial passion on investor interest through regression analysis that controlled for the ten different clips and the fifteen different subjects. Table 4 shows that higher displayed entrepreneurial passion increases investor interest ($B = 0.870$, $p < 0.001$), where high displays of passion result in a 26% increase in investor interest relative to mean interest of 3.4 in the low passion treatment. The patterns are consistent if we disaggregate our investor interest scale and look at the effect of entrepreneurial passion on the individual items measuring investor interest.

Hypothesis 4 argued that higher levels of engagement during the exposure to a pitch partially mediate the effect of displayed entrepreneurial passion on investor interest. Table 5 reveals that the coefficient for passion ($B = 0.758$, $p < 0.01$), undergoes a reduction of 0.112 when engagement is added to the model, as compared to when engagement is not in the model as reported in Table 4 ($B = 0.870$, $p < 0.001$). Disaggregating our investor interest scale, passion undergoes a reduction across all five individual questions when engagement is added, as compared to when engagement is not in the model. These results suggest the possibility of a mediation effect.

Table 6 presents a more structured mediation analysis. The estimation of these models was done using the STATA program for generalized structural equation modelling `gsem`. Following the preferred specifications for models of investor interest and individual engagement developed above, the first equation for investor interest s_i has random intercepts at the subject and venture level. The

Table 3
Neural engagement predicting level of investor interest.

	Investor interest
Neural engagement	0.0553**
	(0.0204)
Constant	2.633***
	(0.468)
Var(ε_i)	1.824***
	(0.117)
Var(α_j)	0.167*
	(0.0663)
Var(δ_k)	0.141*
	(0.0599)
N	147

Standard errors in parentheses $^+ < 0.10$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 4
Causal effect of passion on investor interest.

	Investor interest
Passion	0.870***
	(0.226)
Constant	3.350***
	(0.230)
Var(ε_i)	1.714***
	(0.110)
Var(α_j)	0.222*
	(0.0750)
Var(δ_k)	0.136*
	(0.0573)
N	147

Standard errors in parentheses $^+ < 0.10$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 5
Entrepreneur passion and individual engagement predicting scale of investor interest.

	Investor interest
Passion	0.758**
	(0.284)
Individual engagement	0.0164
	(0.0249)
Constant	3.064***
	(0.490)
Var(ε_i)	1.708***
	(0.109)
Var(α_j)	0.224*
	(0.0752)
Var(δ_k)	0.135*
	(0.0570)
N	147

Standard errors in parentheses $^+ < 0.10$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

second equation for individual engagement e_i has a fixed intercept.

$$s_i = \alpha_j + \delta_k + \beta_e e_i + \beta_p p_i + \varepsilon_i^s$$
$$e_i = \gamma_0 + \gamma_p p_i + \varepsilon_i^e$$

The indirect effect of passion on investor interest through the mediator of individual engagement is given by the product of coefficients $\gamma_p\beta_e$. The total effect $\beta_p + \gamma_p\beta_e$ is the indirect effect plus the direct effect. As Table 6 indicates, the mediated effect represents 0.112 of the 0.870 total effect, or 13%. Although this percentage is non-trivial, the effect is not statistically significant.

Table 6
Mediation effects of passion through individual engagement.

	Investor interest
Indirect effect	0.112
	(0.170)
Direct effect	0.758**
	(0.289)
Total effect	0.870***
	(0.231)
N	147

Standard errors in parentheses $^{+}<0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

7. Discussion

Researchers and practitioners have argued that a founder's passion is central to attracting investor interest (Bussgang, 2010; Hsu et al., 2014; Landström and Mason, 2016; Li et al., 2017; Mitteness et al., 2012; Pollack et al., 2012; Rose, 2008; Sudek, 2006; Warnick et al., 2018). We offer a novel explanation for this phenomenon from the cognitive neuroscience literature: Displayed founder passion affects the neural engagement of investors. That neural engagement, in turn, affects investor interest in funding startup companies, making neural engagement a pathway through which passion affects investor interest. We test this additional explanation using neuro imaging data collected via fMRI while informal investors assess randomly assigned pitches that manipulate displayed founder passion.

We find that informal investors who are randomly assigned a pitch with high founder passion have 26% greater interest relative to a pitch with low founder passion. We find that higher founder passion increases investor neural engagement by 39% over those displaying low passion, and that a one standard deviation increase in neural engagement is associated with an 8% increase in investors' interest in investing in a start-up company relative to the mean. Our findings suggest that neural engagement could partially mediate the passion-investor interest relationship, but we cannot confirm it. The indirect effect is non-trivial in magnitude, but not statistically significant.

The results of this study have several implications. First, there is growing interest in understanding investor decision making in entrepreneurship, with several studies examining the investment choices of professional venture capitalists and other investors (e.g., Anglin et al., 2018; Chen et al., 2009; Clarke et al., 2019; Drover et al., 2017; Huang and Pearce, 2015; Kerr et al., 2011). These efforts have mostly neglected informal investors (Burke et al., 2014; Shane, 2008), which is a significant omission given that informal investors account for the majority of all investments made (Bygrave et al., 2003; Erikson and Sørheim, 2005; Lee and Persson, 2016), and four times the capital put into early stage companies as venture capitalists (Bygrave and Reynolds, 2004).

We contribute to an understanding of how informal investors respond to founders' pitches. Doing so, we explore the extent to which displayed passion influences assessments of new ventures. Drawing on theory and findings from related literature streams, we found that the effect of founder passion influences the decision making of informal investors similarly to that of venture capitalists and members of organized angel groups, even though informal investors are less experienced and thought to make more altruistic decisions (Klyver et al., 2017; Paul et al., 2003).

Next, our study provides evidence that complements and extends existing work on the role of passion in investor decision making. Past findings on the founder passion-investor interest relationship have been mixed (e.g., Chen et al., 2009; Mitteness et al., 2012) and thus inconclusive. We believe this is because most evidence to date has been correlational, which raises the possibility that these correlations could be artifacts of omitted variable bias or reverse causality. Moreover, the use of text to manipulate founder passion and the lack of fully randomized designs limits the confidence with which we can make causal inferences about the passion-interest relationship from existing experimental work. By using a randomized experiment, we are able to contribute new insight on the causal role of founder passion. Moreover, our treatments were pre-recorded, which helps to assuage concerns of reverse causality. We rule out that investors' displayed interest in ventures is what leads entrepreneurs to display more passion.

We show evidence that the theoretical arguments of previous researchers are correct: the founder passion-investor interest relationship is not spurious. There is a ***causal*** effect of founder passion on investor interest. By studying the effect of founder passion on investor interest through a randomized controlled trial we build upon the work of previous scholars who found that founder passion plays an important role in generating investor interest, firmly establishing that such patterns are not merely artifacts of non-experimental approaches, or experiments with less randomization. More broadly, our approach shows how randomized video experiments can be used as a pathway to examine causality, and to advance or refine understandings in venture finance.

Next, our study offers a test of a novel theoretic perspective for why displays of founder passion affect investor interest. Despite growing calls for the incorporation of neuroscientific explanations for many aspects of business (Ashkanasy et al., 2014; Becker et al., 2011, 2015; Nicolaou et al., 2009; Nofal et al., 2018; Powell, 2011; Waytz and Mason, 2013), and entrepreneurship (Day et al., 2017; de Holan, 2014; de Holan and Couffe, 2017; Krueger Jr and Day, 2010; McMullen et al., 2014; Ward et al., 2017), few empirical studies have been conducted. This lack of research has hindered our collective understanding of an important aspect of entrepreneurship: how founders convince investors to provide them with the resources they need to build their businesses. While entrepreneurship scholars have rightly identified founder passion as a key aspect of this process (Cardon et al., 2017; Davis et al., 2017; Hsu et al., 2014; Landström and Mason, 2016; Li et al., 2017; Mitteness et al., 2012; Sudek, 2006; Warnick et al., 2018), this literature has yet to consider an important explanation that requires unpacking the black box of investor brain function. Looking at the process from the perspective of cognitive neuroscience, we see that displayed founder passion leads to greater investor neural engagement, which, in turn, boosts investor interest.

While our findings suggest that neural engagement might partially mediate the passion-investor interest relationship and the indirect effect is non-trivial in magnitude, it is not statistically significant. This outcome raises the question of what the presence or absence of mediation might mean, and raises a pathway for future work. If entrepreneur passion does indeed influence investor interest through neural engagement, then there is support for our novel explanation why entrepreneur passion affects investor interest. If entrepreneur passion does not influence investor interest through neural engagement, then researchers need to explain why both founder passion and investor neural engagement matter independently.

Our finding that higher neural engagement is associated with higher investor interest raises other questions. Neural engagement may be an overlooked explanation for why certain pitch elements tend to influence investors. For instance, storytelling has been shown to influence investor assessments (Lounsbury and Glynn, 2001; Manning and Bejarano, 2017). Perhaps storytelling sways investors by engaging their brains. In a similar vein, perhaps founder attractiveness (Patel and Wolfe, 2019) or asthetics (Chan and Park, 2015) also influence neural engagement of investors, in turn increasing their assessments. Investor neural engagement may influence venture decision making in ways beyond our focus on displayed passion.

Our study also shows the value of cognitive neuroscience techniques to get at theoretical questions not well addressed by empirical designs typically employed by entrepreneurship researchers, such as asking subjects to explain their responses (e.g., Chen et al., 2015). Cognitive neuroscientists have shown that asking subjects to evaluate an experience/stimulus while it is ongoing interferes with the experience (Hsu, 2017). And if the researchers wait until the end of the experience to ask questions, then the answers can potentially suffer from recency and peak-end effects. This means that asking subjects to reflect on their engagement can be flawed. Other approaches, such as eye tracking, also have limitations given that while one might be actively viewing a pitch the mind may be elsewhere. Observing real-time neural activity offers untapped ways to avoid such problems, which is particularly important in entrepreneurship where the decision making process may not be conscious or understood by subjects (Hsu and Yoon, 2015; Venkatraman et al., 2015; Lee and Huang, 2018).

We are by no means the only researchers using cognitive neuroscience to address entrepreneurship questions that previously could not be answered. Lahti et al. (2018) found that entrepreneurs exhibit bonds with their ventures in a similar way that parents bond with their children (via similarities in the brain's reward system), which offers important implications for understanding important questions such as why founders persist with poorly performing ventures.[5] Other work has sought to address the long unanswered question of whether entrepreneurs think differently from non-entrepreneurs. Deploying EEG, Ortiz-Terán et al. (2013) found that entrepreneurs respond differently than non-entrepreneurs while engaging in decision tasks (Ortiz-Terán et al., 2013). In a similar vein, using cognitive brain mapping via EEG, Zaro et al. (2016) revealed that entrepreneurs brains appear to function differently than non-entrepreneurs while assessing business opportunities.

Within entrepreneurial finance, Genevsky and Knutson (2015) examine whether neural data can predict the success of microloan requests on Kiva. Findings suggest neural affective mechanisms are correlated with microloan decisions and charitable giving. Moreover, Genevsky et al. (2017) exposed subjects to pictures and texts associated with reward-based crowdfunding campaigns for documentaries (e.g., Kickstarter), and found that neural data can forecast aggregate behavior of crowdfunding outcomes.

Our study departs from those above in several ways. Notably, we utilized videos of pitches in our neural experiment, whereas most neuroscience studies use pictures or written text. Thus, our effort offers a first look at how brains respond to natural real-world phenomena as they unfold in the entrepreneurial context. We also study correlations in a non-traditional way by observing brains synchronicity rather than signature regions of interest in individual brains. While traditionally neuroscientists study individual brains, looking for specific neural correlates of a stimulus, recently, researchers are uncovering the value of studying alignment across multiple brains (Barnett and Cerf, 2017; Denworth, 2019). Moment to moment coupling of brains can shed light on reactions in new ways.

8. Limitations and avenues for future research

Our study is not without limitations. We examine only an elevator pitch, which is typically delivered in the beginning of the fundraising process. Thus, our findings may not generalize to other types of pitches delivered later in the process. Future work might assess pitches of different lengths to test how engagement is modulated with respect to length.

Moreover, we look only at informal investors. Due to the cost and challenges of obtaining experts, it is common for preliminary investigations to utilize naïve subjects (Chen et al., 1998; Chen et al., 2009; Fiet and Patel, 2008; Genevsky and Knutson, 2015; Genevsky et al., 2017; Hsu et al., 2017; Zampetakis et al., 2017). If professional investors respond differently to pitches than the subjects we recruited, our results may be limited to naïve investors. However, it is also possible that venture capitalists and members of angel groups will respond to founder passion in the same way as informal investors because all of those investors are human beings

---

[5] The implication being that the reason might be the same brain circuitry that accounts for the unwillingness of parents to give up on problem children.

whose brains operate similarly. Some neuroscience research would suggest that investors may respond similarly to passion in founder pitches because it has shown that human beings respond similarly to movie trailers, compelling speeches, advertising pitches, etc. (Barnett and Cerf, 2017; Nummenmaa et al., 2012; Schmälzle et al., 2015). These studies suggest content impacts those brains in a way that can 'override' idiosyncratic preferences.

Other neuroscience research suggests the brain functioning of experts and novices may differ. For instance, expert marksmen engage their brains differently than novice shooters during the aiming period—reflecting stronger theta activity located at the medial frontal cortex and the anterior cingulate area (Haufler et al., 2000). Additionally, examining golfers in pre-shot routines, novice golfers engaged the posterior cingulate, the amygdala–forebrain complex, and the basal ganglia, whereas experts primarily engaged the superior parietal lobule, the dorsal lateral premotor area, and the occipital area (Milton et al., 2007).

Building upon extant neuroscience research centering on novice and experts, scholars may wish to repeat our study with different investor types to explore similarities and differences in neural engagement and other observed brain function. Future research might examine the conditions under which engagement is triggered, and how/when it influences pitch assessments. Researchers might examine how specific regions of interest vary with domain or investment expertise as pitches are assessed. That is, do expert versus non-expert brains differ in their assessments of pitches, and pitch variants such as passion? Are favorable or unfavorable assessments driven by different neural sites? Specifically, exploring key sites, such as the timing and extent of nucleus accumbens activation (e.g., associated with the anticipation of monetary rewards), might assist in explaining the key underpinnings of what drives pitch assessments of different investor types. Additionally, given that one may suspect that the evaluation of a pitch is also driven by motivation and assessment of the value of the content, one may expect a difference in activation with systems that are typically implicated with those functions. Specifically, one may expect a difference in Frontal Alpha Asymmetry (FAA – a metric used primarily in EEG to quantify approach-avoidance or positive-negative attitudes toward experienced content) when viewing the clips. Finally, we can expect that expert investors may draw more of their decision-making process from past experience or from an ability to introspect on the offer compared to other existing offers in their portfolio. If that is indeed the case, then we expect activation in memory-implicated sites (i.e. hippocampus, entorhinal cortex and generally Medial Temporal Lobe sites) alongside the posterior cingulate – suggesting mental reflection and introspection.

It has not escaped our notice that we tested pitches for only a small number of venture concepts. While we have no evidence to the contrary, our findings may not generalize beyond the ventures we examined.

We believe cognitive neuroscience has relevance for entrepreneurship, though we do not see it as a silver bullet (Becker et al., 2011; Healey and Hodgkinson, 2014). Cognitive neuroscientists offer a different explanation for the founder passion-investor interest relationship than that prevailing in the entrepreneurship literature. Their techniques permitted the testing of that explanation. We found evidence for this alternative explanation. Thus, we follow Becker and Cropanzano (2010) in arguing that neuroscience methods should not be viewed as a replacement for current methods, but rather as a complement. These methods provide insight into specific aspects of entrepreneurship for particular questions. Other questions in entrepreneurship may not be as well suited for neural-based investigations.

In research involving highly emotional content, there is a risk of emotional carry-over effects. That is, having the thoughts and feelings about a highly emotional stimulus (e.g. high passion pitch) contaminate the neural response to a more neutral stimulus (e.g. a low passion pitch). While this risk is a limitation of neuroscience studies—as the measures of one effect may contain signal from another effect, we believe that two aspects of our design make it highly unlikely to be a problem. First, we used a short time interval and a fixation cross at the end of each clip to increase the refractory period between stimulus. Second, we employed a random ordering of clips.

Because of our approach to mediation, and the measurement of our variables, we cannot rule out the possibility of confounding effects. While we recognize this limitation, future researchers might conduct further tests, such as randomly manipulating engagement through channels in addition to displayed passion to explore the influence on investor interest.[6] Doing so could help to confirm or reject the causal effect of engagement on investor interest, and the mediation role.

Our study used fMRI and therefore is subject to the limitations of this method of measurement. It is possible that our results are artifacts of the method used to capture the fMRI data and would not be present when subjects are watching pitches in the wild.

9. Practical implications

Our results also have implications for the practice of entrepreneurship. Every year, hundreds of thousands of entrepreneurs make pitches to financiers across the globe (Chen et al., 2009; Kanze et al., 2018; Short et al., 2017). Those pitches are widely recognized as the gateway to investor funding. Effective pitching is typically necessary to get investors to consider funding, hence recent research is beginning to untangle how entrepreneur pitch training influences investor assessments (Clingingsmith and Shane, 2018). Our results show that at least one aspect of pitching that can be taught increases the odds that founders will attract investor interest. By pitching in a way that shows founder passion, entrepreneurs can considerably increase investor engagment and in turn increase the odds that investors will further investigate financing a new venture.

Moreover, measuring engagement directly from the brain can predict which pitches are more or less likely to be effective. This approach can, therefore, both improve the pitch process by making earlier predictions as well as train entrepreneurs to do a better job of pitching investors. Much as the world of neuromarketing is increasingly using neural data to glean insights about viewer content

---

[6] We thank an anonymous reviewer for this observation.

(Chen et al., 2015; Hsu and Yoon, 2015; Smidts et al., 2014), and adjusting that content for optimal responses, entrepreneurs and their trainers, can begin using neural data to refine pitch presentations and associated success rates.

10. Conclusion

Our findings provide new evidence on neural responses to entrepreneur pitches. We hope that our cross-disciplinary effort serves to motivate other scholars to further advance understandings of neural activity in the domain of entrepreneurship.

Acknowledgements

We thank the University of Oklahoma and Northwestern University for the funding and resources that made this study possible.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbusvent.2019.105949.

References

Anglin, A.H., Short, J.C., Drover, W., Stevenson, R.M., McKenny, A.F., Allison, T.H., 2018. The power of positivity? The influence of positive psychological capital language on crowdfunding performance. J. Bus. Ventur. 33 (4), 470–492.

Ariely, D., Berns, G.S., 2010. Neuromarketing: the hope and hype of neuroimaging in business. Nat. Rev. Neurosci. 11 (4), 284.

Ashkanasy, N.M., Becker, W.J., Waldman, D.A., 2014. Neuroscience and organizational behavior: avoiding both neuro-euphoria and neuro-phobia. J. Organ. Behav. 35 (7), 909–919.

Barnett, S.B., Cerf, M., 2017. A ticket for your thoughts: method for predicting content recall and sales using neural similarity of moviegoers. J. Consum. Res. 44 (1), 160–181.

Barnett, S.B., White, H.M., Cerf, M., 2016. Keep it Simple Stimuli: Brain-Vetted Elements of Movie Trailers Predict Opening Weekend Ticket Sales. ACR North American Advances.

Baron, R.A., 2008. The role of affect in the entrepreneurial process. Acad. Manag. Rev. 33 (2), 328–340.

Becker, W.J., Cropanzano, R., 2010. Organizational neuroscience: the promise and prospects of an emerging discipline. J. Organ. Behav. 31 (7), 1055–1059.

Becker, W.J., Cropanzano, R., Sanfey, A.G., 2011. Organizational neuroscience: taking organizational theory inside the neural black box. J. Manag. 37 (4), 933–961.

Becker, W.J., Volk, S., Ward, M.K., 2015. Leveraging neuroscience for smarter approaches to workplace intelligence. Hum. Resour. Manag. Rev. 25 (1), 56–67.

Boksem, M.A., Smidts, A., 2015. Brain responses to movie trailers predict individual preferences for movies and their population-wide commercial success. J. Mark. Res. 52 (4), 482–492.

Broekens, J., Qu, C., Brinkman, W.P., 2012. Dynamic Facial Expression of Emotion Made Easy. *arXiv preprint arXiv:1211.4500*.

Burke, A., Hartog, C., Ichou, A., van Stel, A., 2011. What determines the level of informal venture finance investment?Market clearing forces and gender effects. In: EIM Research Reports, . https://core.ac.uk/download/pdf/6423115.pdf.

Burke, A., van Stel, A., Hartog, C., Ichou, A., 2014. What determines the level of informal venture finance investment? Market clearing forces and gender effects. Small Bus. Econ. 42 (3), 467–484.

Bussgang, J., 2010. Mastering the VC Game: A Venture Capital Insider Reveals how to Get From Start-up to IPO on your Terms. Penguin.

Bygrave, W.D., Reynolds, P.D., 2004. Who Finances Startups in the USA? A Comprehensive Survey of Informal Investors, 1999–2003. Paper to the Babson-Kaufman Entrepreneurship Research Conference. University of Strathclyde, Glasgow (3-5 June).

Bygrave, W., Hay, M., Ng, E., Reynolds, P., 2003. Executive forum: a study of informal investing in 29 nations composing the global entrepreneurship monitor. Venture Capital: An International Journal of Entrepreneurial Finance 5 (2), 101–116.

Cardon, M.S., 2008. Is passion contagious? The transference of entrepreneurial passion to employees. Hum. Resour. Manag. Rev. 18 (2), 77–86.

Cardon, M.S., Sudek, R., Mitteness, C., 2009. The impact of perceived entrepreneurial passion on angel investing. Frontiers of Entrepreneurship Research 29 (2), 1.

Cardon, M.S., Gregoire, D.A., Stevens, C.E., Patel, P.C., 2013. Measuring entrepreneurial passion: conceptual foundations and scale validation. J. Bus. Ventur. 28 (3), 373–396.

Cardon, M.S., Mitteness, C., Sudek, R., 2017. Motivational cues and angel investing: interactions among enthusiasm, preparedness, and commitment. Entrepreneurship Theory and Practice 41 (6), 1057–1085.

Carpentier, C., Suret, J.M., 2015. Angel group members' decision process and rejection criteria: a longitudinal analysis. J. Bus. Ventur. 30 (6), 808–821.

Cerf, M., Frady, E.P., Koch, C., 2009. Faces and text attract gaze independent of the task: experimental data and computer model. J. Vis. 9 (12), 1–15.

Chan, C.R., Park, H.D., 2015. How images and color in business plans influence venture investment screening decisions. J. Bus. Ventur. 30 (5), 732–748.

Chen, C.C., Greene, P.G., Crick, A., 1998. Does entrepreneurial self-efficacy distinguish entrepreneurs from managers? J. Bus. Ventur. 13 (4), 295–316.

Chen, X.P., Yao, X., Kotha, S., 2009. Entrepreneur passion and preparedness in business plan presentations: a persuasion analysis of venture capitalists' funding decisions. Acad. Manag. J. 52 (1), 199–214.

Chen, Y.P., Nelson, L.D., Hsu, M., 2015. From “where” to “what”: distributed representations of brand associations in the human brain. J. Mark. Res. 52 (4), 453–466.

Clarke, J.S., Cornelissen, J.P., Healey, M.P., 2019. Actions speak louder than words: How figurative language and gesturing in entrepreneurial pitches influences investment judgments. Acad. Manag. J. 62 (2), 335–360.

Clingingsmith, D., Shane, S., 2018. Training aspiring entrepreneurs to pitch experienced investors. Manag. Sci. 64 (11), 5164–5179.

Davis, B.C., Hmieleski, K.M., Webb, J.W., Coombs, J.E., 2017. Funders' positive affective reactions to entrepreneurs' crowdfunding pitches: the influence of perceived product creativity and entrepreneurial passion. J. Bus. Ventur. 32 (1), 90–106.

Day, M., Boardman, M.C., Krueger, N.F. (Eds.), 2017. Handbook of Research Methodologies and Design in Neuroentrepreneurship. Edward Elgar Publishing.

de Holan, P.M., 2014. It's all in your head: why we need neuroentrepreneurship. J. Manag. Inq. 23 (1), 93–97.

de Holan, P.M., Couffe, C., 2017. 4. Unpacking neuroentrepreneurship: conducting entrepreneurship research with EEG technologies. In: Handbook of Research Methodologies and Design in Neuroentrepreneurship, pp. 94–116.

Denworth, L., 2019. “Hyperscans” show how brains sync as people interact. Sci. Am. https://www.scientificamerican.com/article/hyperscans-show-how-brains-sync-as-people-interact/?redirect=1.

DePaulo, B.M., 1992. Nonverbal behavior and self-presentation. Psychol. Bull. 111 (2), 203–243.

Dimoka, A., 2011. Brain mapping of psychological processes with psychometric scales: an fMRI method for social neuroscience. NeuroImage 54, S263–S271.

Dmochowski, J.P., Sajda, P., Dias, J., Parra, L.C., 2012. Correlated components of ongoing EEG point to emotionally laden attention–a possible marker of engagement? Front. Hum. Neurosci. 6 (112), 1–9.

Dmochowski, J.P., Bezdek, M.A., Abelson, B.P., Johnson, J.S., Schumacher, E.H., Parra, L.C., 2014. Audience preferences are predicted by temporal reliability of neural processing. Nat. Commun. 5, 4567.

Drnovsek, M., Cardon, M.S., Patel, P.C., 2016. Direct and indirect effects of passion on growing technology ventures. Strateg. Entrep. J. 10 (2), 194–213.

Drover, W., Busenitz, L., Matusik, S., Townsend, D., Anglin, A., Dushnitsky, G., 2017. A review and road map of entrepreneurial equity financing research: venture capital, corporate venture capital, angel investment, crowdfunding, and accelerators. J. Manag. 43 (6), 1820–1853.

Erikson, T., Sørheim, R., 2005. ‘Technology angels’ and other informal investors. Technovation 25 (5), 489–496.

Fiet, J.O., Patel, P.C., 2008. Entrepreneurial discovery as constrained, systematic search. Small Bus. Econ. 30, 215–229.

Gasca, P., 2014. Master these 4 simple pitching concepts to capture a Room's attention. In: Entrepreneur Magazine, . https://www.entrepreneur.com/article/239666.

GEM, 2016. Global Entrepreneurship Monitor. Special Topic Report: Entrepreneurial Finance. https://www.gemconsortium.org/report/gem-2015-2016-report-on-entrepreneurial-financing.

Genevsky, A., Knutson, B., 2015. Neural affective mechanisms predict market-level microlending. Psychol. Sci. 26 (9), 1411–1422.

Genevsky, A., Yoon, C., Knutson, B., 2017. When brain beats behavior: neuroforecasting crowdfunding outcomes. J. Neurosci. 37 (36), 8625–8634.

Glimcher, P.W., Fehr, E. (Eds.), 2013. Neuroeconomics: Decision Making and the Brain. Academic Press.

Hasson, U., Nir, Y., Levy, I., Fuhrmann, G., Malach, R., 2004. Intersubject synchronization of cortical activity during natural vision. Science 303 (5664), 1634–1640.

Hasson, U., Landesman, O., Knappmeyer, B., Vallines, I., Rubin, N., Heeger, D.J., 2008. Neurocinematics: the neuroscience of film. Projections 2 (1), 1–26.

Hatfield, E., Cacioppo, J.T., Rapson, R.L., 1993. Emotional contagion. Curr. Dir. Psychol. Sci. 2 (3), 96–100.

Haufler, A.J., Spalding, T.W., Santa Maria, D.L., Hatfield, B.D., 2000. Neuro-cognitive activity during a self-paced visuospatial task: comparative EEG profiles in marksmen and novice shooters. Biol. Psychol. 53 (2–3), 131–160.

Healey, M.P., Hodgkinson, G.P., 2014. Rethinking the philosophical and theoretical foundations of organizational neuroscience: a critical realist alternative. Hum. Relat. 67 (7), 765–792.

Heeger, D.J., Ress, D., 2002. What does fMRI tell us about neuronal activity? Nat. Rev. Neurosci. 3 (2), 142.

Hilaly, A., 2019. https://www.sequoiacap.com/article/how-to-present-to-investors/.

Hsu, M., 2017. Neuromarketing: inside the mind of the consumer. Calif. Manag. Rev. 59 (4), 5–22.

Hsu, M., Yoon, C., 2015. The neuroscience of consumer choice. Curr. Opin. Behav. Sci. 5, 116–121.

Hsu, D.K., Haynie, J.M., Simmons, S.A., McKelvie, A., 2014. What matters, matters differently: a conjoint analysis of the decision policies of angel and venture capital investors. Ventur. Cap. 16 (1), 1–25.

Hsu, D.K., Simmons, S.A., Wieland, A.M., 2017. Designing entrepreneurship experiments: a review, typology, and research agenda. Organ. Res. Methods 20 (3), 379–412.

Huang, L., Pearce, J.L., 2015. Managing the unknowable: the effectiveness of early-stage investor gut feel in entrepreneurial investment decisions. Adm. Sci. Q. 60 (4), 634–670.

Kanze, D., Huang, L., Conley, M.A., Higgins, E.T., 2018. We ask men to win and women not to lose: closing the gender gap in startup funding. Acad. Manag. J. 61 (2), 586–614.

Kerr, W.R., Lerner, J., Schoar, A., 2011. The consequences of entrepreneurial finance: evidence from angel financings. Rev. Financ. Stud. 27 (1), 20–55.

Klyver, K., Lindsay, N.J., Suleiman, K., Hancock, G., 2017. Altruistic investment decision behavior in early-stage ventures. Small Bus. Econ. 48 (1), 135–152.

Cerf, M., Garcia-Garcia, M., Kotler, P., 2017. Consumer Neuroscience. MIT Press, Boston.

Krueger Jr., N.F., Day, M., 2010. Looking forward, looking backward: from entrepreneurial cognition to neuroentrepreneurship. In: Handbook of Entrepreneurship Research. Springer, New York, pp. 321–357.

Lahti, T., Halko, M.L., Karagozoglu, N., Wincent, J., 2018. Why and how do founding entrepreneurs bond with their ventures? Neural correlates of entrepreneurial and parental bonding. J. Bus. Ventur. https://doi.org/10.1016/j.jbusvent.2018.05.001.

Landström, H., Mason, C., 2016. Handbook of Research on Business Angels. Edward Elgar Publishing.

Lankinen, K., Saari, J., Hari, R., Koskinen, M., 2014. Intersubject consistency of cortical MEG signals during movie viewing. NeuroImage 92, 217–224.

Laureiro-Martínez, D., Brusoni, S., Canessa, N., Zollo, M., 2015. Understanding the exploration–exploitation dilemma: an fMRI study of attention control and decision-making performance. Strateg. Manag. J. 36 (3), 319–338.

Lee, M., Huang, L., 2018. Gender bias, social impact framing, and evaluation of entrepreneurial ventures. Organ. Sci. 29 (1), 1–16.

Lee, S., Persson, P., 2016. Financing from family and friends. Rev. Financ. Stud. 29 (9), 2341–2386.

Li, J.J., Chen, X.P., Kotha, S., Fisher, G., 2017. Catching fire and spreading it: a glimpse into displayed entrepreneurial passion in crowdfunding campaigns. J. Appl. Psychol. 102 (7), 1075–1090.

Lounsbury, M., Glynn, M.A., 2001. Cultural entrepreneurship: stories, legitimacy, and the acquisition of resources. Strateg. Manag. J. 22 (6–7), 545–564.

Mackay, M., Cerf, M., Koch, C., 2012. Evidence for two distinct mechanisms directing gaze in natural scenes. J. Vis. 12 (4), 1–12.

MacMillan, I.C., Zemann, L., Subbanarasimha, P.N., 1987. Criteria distinguishing successful from unsuccessful ventures in the venture screening process. J. Bus. Ventur. 2 (2), 123–137.

Manning, S., Bejarano, T.A., 2017. Convincing the crowd: entrepreneurial storytelling in crowdfunding campaigns. Strateg. Organ. 15 (2), 194–219.

McMullen, J.S., Wood, M.S., Palich, L.E., 2014. Entrepreneurial cognition and social cognitive neuroscience. In: Handbook of Entrepreneurial Cognition, pp. 316–363.

Miller, N., Maruyama, G., Beaber, R.J., Valone, K., 1976. Speed of speech and persuasion. J. Pers. Soc. Psychol. 34 (4), 615.

Milosavljevic, M., Cerf, M., 2008. First attention then intention. Int. J. Advert. 27 (3), 381–398.

Milton, J., Solodkin, A., Hluštík, P., Small, S.L., 2007. The mind of expert motor performance is cool and focused. NeuroImage 35 (2), 804–813.

Mitteness, C., Sudek, R., Cardon, M.S., 2012. Angel investor characteristics that determine whether perceived passion leads to higher evaluations of funding potential. J. Bus. Ventur. 27 (5), 592–606.

Moè, A., 2016. Does displayed enthusiasm favour recall, intrinsic motivation and time estimation? Cognit. Emot. 30 (7), 1361–1369.

Mueller, B.A., Wolfe, M.T., Syed, I., 2017. Passion and grit: an exploration of the pathways leading to venture success. J. Bus. Ventur. 32 (3), 260–279.

Murnieks, C., Cardon, M., Sudek, R., White, T., Brooks, W., 2016. Drawn to the fire: the role of passion, tenacity, and inspirational leadership in angel investing. J. Bus. Ventur. 31, 468–484.

Nicolaou, N., Shane, S., 2014. Biology, neuroscience, and entrepreneurship. J. Manag. Inq. 23 (1), 98–100.

Nicolaou, N., Shane, S., Cherkas, L., Spector, T.D., 2009. Opportunity recognition and the tendency to be an entrepreneur: a bivariate genetics perspective. Organ. Behav. Hum. Decis. Process. 110 (2), 108–117.

Nofal, A.M., Nicolaou, N., Symeonidou, N., Shane, S., 2018. Biology and management: a review, critique, and research agenda. J. Manag. 44 (1), 7–31.

Nummenmaa, L., Glerean, E., Viinikainen, M., Jääskeläinen, I.P., Hari, R., Sams, M., 2012. Emotions promote social interaction by synchronizing brain activity across individuals. Proc. Natl. Acad. Sci. 109 (24), 9599–9604.

Ortiz-Terán, E., Turrero, A., Santos, J.M., Bryant, P.T., Ortiz, T., Ortiz-Terán, E., Ortiz, T., 2013. Brain cortical organization in entrepreneurs during a visual Stroop decision task. Neurosci. Neuroecon. 33.

Patel, P.C., Wolfe, M.T., 2019. In the eye of the beholder? The returns to beauty and IQ for the self-employed. Strateg. Entrep. J. https://doi.org/10.1002/sej.1323.

Patrick, B.C., Hisley, J., Kempler, T., 2000. What's everybody so excited about? The effects of teacher enthusiasm on student intrinsic motivation and vitality. J. Exp. Educ. 68 (3), 217–236.

Paul, S., Whittam, G., Johnston, J.B., 2003. The operation of the informal venture capital market in Scotland. Ventur. Cap. 5 (4), 313–335.

Petty, J.S., Gruber, M., 2011. In pursuit of the real deal: a longitudinal study of VC decision making. J. Bus. Ventur. 26 (2), 172–188.

Pollack, J.M., Rutherford, M.W., Nagy, B.G., 2012. Preparedness and cognitive legitimacy as antecedents of new venture funding in televised business pitches. Entrepreneurship Theory and Practice 36 (5), 915–939.

Poulsen, A.T., Kamronn, S., Dmochowski, J., Parra, L.C., Hansen, L.K., 2017. EEG in the classroom: synchronised neural recordings during video presentation. Sci. Rep. 7, 43916.

Powell, T.C., 2011. Neurostrategy. Strateg. Manag. J. 32 (13), 1484–1499.

Robb, A.M., Robinson, D.T., 2014. The capital structure decisions of new firms. Rev. Financ. Stud. 27 (1), 153–179.

Rose, D., 2008. How to pitch a VC. https://www.ted.com/talks/david_s_rose_on_pitching_to_vcs/up-next#t-155899.

Schmälzle, R., Häcker, F.E., Honey, C.J., Hasson, U., 2015. Engaged listeners: shared neural processing of powerful political speeches. Soc. Cogn. Affect. Neurosci. 10 (8), 1137–1143.

Shane, S., 2008. Fools Gold: The Truth behind Angel Investing in America. Oxford University Press, New York.

Short, J.C., Ketchen Jr., D.J., McKenny, A.F., Allison, T.H., Ireland, R.D., 2017. Research on crowdfunding: reviewing the (very recent) past and celebrating the present. Entrepreneurship Theory and Practice 41 (2), 149–160.

Singh, K.D., 2012. Which "neural activity" do you mean? fMRI, MEG, oscillations and neurotransmitters. NeuroImage 62 (2), 1121–1130.

Smidts, A., Hsu, M., Sanfey, A.G., Boksem, M.A., Ebstein, R.B., Huettel, S.A., Kable, J., Karmarker, U., Kitayama, S., Knutson, B., Liberzon, I., Lohrenz, T., Stallen, M., Yoon, C., 2014. Advancing consumer neuroscience. Mark. Lett. 25 (3), 257–267.

Sudek, R., 2006. Angel investment criteria. J. Small Bus. Strateg. 17 (2), 89–103.

Talairach, J., Tournoux, P., 1988. Co-Planar Stereotaxic Atlas of the Human Brain: 3-Dimensional Proportional System: An Approach to Cerebral Imaging. Thieme, Stuttgart.

Vallerand, R.J., Houlfort, N., 2003. Passion at Work. Emerging Perspectives on Values in Organizations. pp. 175–204.

Venkatraman, V., Dimoka, A., Pavlou, P.A., Vo, K., Hampton, W., Bollinger, B., Masakazu, M., Winder, R., 2015. Predicting advertising success beyond traditional measures: new insights from neurophysiological methods and market response modeling. J. Mark. Res. 52 (4), 436–452.

Ward, M.K., Reeck, C., Becker, W., 2017. A brief primer on using functional magnetic resonance imaging (fMRI) in entrepreneurship research. In: Handbook of Research Methodologies and Design in Neuroentrepreneurship, pp. 120.

Warnick, B.J., Murnieks, C.Y., McMullen, J.S., Brooks, W.T., 2018. Passion for entrepreneurship or passion for the product? A conjoint analysis of angel and VC decision-making. J. Bus. Ventur. 33 (3), 315–332.

Watson, D., Clark, L.A., Tellegen, A., 1988. Development and validation of brief measures of positive and negative affect: the PANAS scales. J. Pers. Soc. Psychol. 54 (6), 1063.

Waytz, A., Mason, M., 2013. Your brain at work. What a new approach to neuroscience can teach us about management. Harv. Bus. Rev. 91 (7–8), 102–111.

Williams, D.W., Wood, M.S., Mitchell, J.R., Urbig, D., 2019. Applying experimental methods to advance entrepreneurship research: on the need for and publication of experiments. J. Bus. Ventur. 34 (2), 215–223.

Zacharakis, A.L., Shepherd, D.A., 2001. The nature of information and overconfidence on venture capitalists' decision making. J. Bus. Ventur. 16 (4), 311–332.

Zampetakis, L.A., Kafetsios, K., Moustakis, V., 2017. Using emotional persuasion for changing attitudes towards entrepreneurship: an interpersonal perspective. J. Bus. Ventur. Insights 7, 50–54.

Zaro, M., da Cruz Fagundes, L., Rocha, F., Nunes, W., 2016. Cognitive brain mapping used in the study of entrepreneurial behavior–pilot test with the use of electroencephalogram–EEG during the process of identification of business opportunities. American Journal of Educational Research 4 (6), 472–478.

Appendix

Appendix Table 1: Multilevel models for Investor Interest

	(1)	(2)	(3)	(4)	(5)	(6)
Passion	0.765**	0.893***	0.731**	0.870***	0.895***	0.870***
	(0.237)	(0.231)	(0.233)	(0.226)	(0.263)	(0.226)
Constant	3.397***	3.337***	3.415***	3.350***	3.358***	3.350***
	(0.168)	(0.199)	(0.196)	(0.230)	(0.224)	(0.230)
Var(ε_i)	2.061***	1.863***	1.945***	1.714***	1.616***	1.714***
	(0.120)	(0.115)	(0.118)	(0.110)	(0.109)	(0.110)
Var(α_j)		0.201*		0.222*	0.200*	0.222*
		(0.0737)		(0.0750)	(0.0772)	(0.0750)
Var(δ_k)			0.115*	0.136*	0.137*	0.136*
			(0.0559)	(0.0573)	(0.0565)	(0.0573)
Var(β_j)					0.305	
					(0.161)	
Var(β_k)						4.62e-12*
						(2.78e-11)
N	147	147	147	147	147	147
AIC	529.4	527.4	529.2	526.0	526.6	528.0

Standard errors in parentheses $^{+}$ <0.10, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix Table 2: Multilevel models for Individual Engagement

	(1)	(2)	(3)	(4)
Passion	6.810***	6.810***	6.810***	6.810***
	(0.734)	(0.734)	(0.734)	(0.734)
Constant	17.40***	17.40***	17.40***	17.40***
	(0.521)	(0.521)	(0.521)	(0.521)
Var(ε_i)	19.79***	19.79***	19.79***	19.79***
	(1.154)	(1.154)	(1.154)	(1.154)
Var(α_j)		1.95e-22***		1.23e-18
		(1.11e-21)		(4.68e-16)
Var(δ_k)			3.93e-23***	2.20e-21***
			(2.52e-22)	(1.39e-20)
N	147	147	147	147
AIC	862.0	864.0	864.0	866.0

Standard errors in parentheses $^{+}$ <0.10, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix Table 3: Region-Specific Analysis*

* For each ROI (note, regions sizes vary in number of voxels; see Harvard-Oxford Brain atlas for region size and boundaries) we computed the minimum, maximum, mean and standard-deviation of the CBC across all subjects and clip, within an experimental condition (high-passion and low-passion). For the minimum/maximum correlations, we note the values and the clip in which they occurred. In bold are the three regions that showed the biggest contrast in activation between conditions. Those are: 1. The right Inferior Frontal Gyrus, which has been implicated with level of impulse control through inhibition and risk aversion (Aron et al., 2004). The left Supramarginal gyrus, which is implicated with interpreting tactile sensory data and, among right-handed subjects (all of our subject pool), with increased activity when making phonological word choices (Christopoulos et al., 2009; Carlson, 2012). The left Temporal Occipital Fusiform Cortex, which is broadly implicated, among numerous other functions, with word recognition and category identification. To test the significance of the activation within each ROI (given the smaller dataset pool, we used 1,000 shuffles of the data for each ROI, using the same numbers but stripping the clip x subject labels and compared the original correlation mean to that of the distribution. No ROI was significant at the 0.05 level, correcting for multiple comparisons.

Cortical Sites	**Laterality**	**Harvard-Oxford Index**	**ROI Index**	**High Displayed Passion**						**Low Displayed Passion**					
				Min CBC	**Min CBC Stimulus**	**Max CBC**	**Max CBC Stimulus**	**Mean CBC**	**STD CBC**	**Min CBC**	**Min CBC Stimulus**	**Max CBC**	**Max CBC Stimulus**	**Mean CBC**	**STD CBC**
Frontal Pole	L	1	1	-0.84	6a	0.81	6a	-0.04	0.36	-0.9	6b	0.83	9b	0.01	0.35
Frontal Pole	R	2	2	-0.71	5a	0.8	10a	-0.01	0.33	-0.85	7b	0.8	3b	-0.02	0.38
Insular Cortex	L	3	3	-0.85	5a	0.86	10a	0	0.35	-0.79	2b	0.8	7b	-0.02	0.33
Insular Cortex	R	4	4	-0.73	5a	0.83	1a	0.04	0.35	-0.84	8b	0.8	4b	-0.03	0.35
Superior Frontal Gyrus	L	5	5	-0.69	1a	0.79	3a	0.04	0.33	-0.72	10b	0.75	9b	0.03	0.3
Superior Frontal Gyrus	R	6	6	-0.71	1a	0.86	1a	-0.01	0.34	-0.73	6b	0.82	8b	0.01	0.31
Middle Frontal Gyrus	L	7	7	-0.86	1a	0.86	2a	0.01	0.34	-0.73	2b	0.85	9b	0.02	0.33
Middle Frontal Gyrus	R	8	8	-0.73	10a	0.78	3a	0.03	0.33	-0.82	2b	0.86	4b	0	0.34
Inferior Frontal Gyrus, pars triangularis	L	9	9	-0.76	4a	0.9	4a	0.07	0.38	-0.8	3b	0.85	8b	0.01	0.36
Inferior Frontal Gyrus, pars triangularis	**R**	**10**	**10**	**-0.89**	**5a**	**0.89**	**9a**	**0.1**	**0.37**	**-0.82**	**5b**	**0.95**	**3b**	**-0.01**	**0.42**
Inferior Frontal Gyrus, pars opercularis	L	11	11	-0.72	10a	0.95	3a	0.06	0.38	-0.91	4b	0.81	5b	-0.02	0.41
Inferior Frontal Gyrus, pars opercularis	R	12	12	-0.82	1a	0.8	9a	0	0.38	-0.8	4b	0.89	3b	0.01	0.36
Precentral Gyrus	L	13	13	-0.76	1a	0.92	4a	0.07	0.4	-0.85	9b	0.91	10b	0	0.44

Precentral Gyrus	R	14	14	-0.89	1a	0.95	1a	0.03	0.35	-0.75	4b	0.77	9b	0	0.34
Temporal Pole	L	15	15	-0.74	3a	0.87	10a	0.07	0.34	-0.78	4b	0.88	7b	0.01	0.33
Temporal Pole	R	16	16	-0.72	3a	0.77	3a	-0.04	0.34	-0.7	8b	0.75	4b	-0.02	0.34
Superior Temporal Gyrus, anterior division	L	17	17	-0.71	7a	0.91	10a	0.04	0.34	-0.87	4b	0.75	4b	-0.02	0.38
Superior Temporal Gyrus, anterior division	R	18	18	-0.79	1a	0.79	3a	-0.04	0.35	-0.72	7b	0.74	10b	-0.03	0.33
Superior Temporal Gyrus, posterior division	L	19	19	-0.75	4a	0.93	10a	-0.01	0.33	-0.85	7b	0.79	9b	0.01	0.37
Superior Temporal Gyrus, posterior division	R	20	20	-0.86	6a	0.79	5a	0.02	0.35	-0.77	5b	0.78	6b	0.01	0.36
Middle Temporal Gyrus, anterior division	L	21	21	-0.82	7a	0.88	5a	0.02	0.36	-0.89	2b	0.82	4b	0.04	0.34
Middle Temporal Gyrus, anterior division	R	22	22	-0.77	5a	0.82	2a	0.05	0.33	-0.84	2b	0.81	5b	-0.01	0.36
Middle Temporal Gyrus, posterior division	L	23	23	-0.84	9a	0.76	1a	-0.01	0.33	-0.68	9b	0.77	7b	-0.01	0.35
Middle Temporal Gyrus, posterior division	R	24	24	-0.88	3a	0.88	1a	-0.02	0.34	-0.82	3b	0.68	4b	-0.01	0.34
Middle Temporal Gyrus, temporooccipital part	L	25	25	-0.72	4a	0.79	10a	0.01	0.36	-0.8	4b	0.9	2b	-0.02	0.34
Middle Temporal Gyrus, temporooccipital part	R	26	26	-0.78	1a	0.86	10a	0.09	0.35	-0.85	2b	0.81	9b	0.02	0.34
Inferior Temporal Gyrus, anterior division	L	27	27	-0.78	3a	0.75	3a	0.02	0.32	-0.81	4b	0.76	8b	0.04	0.28
Inferior Temporal Gyrus, anterior division	R	28	28	-0.86	3a	0.82	3a	0.02	0.34	-0.76	8b	0.8	7b	0.02	0.32
Inferior Temporal Gyrus, posterior division	L	29	29	-0.74	10a	0.85	5a	0.07	0.33	-0.69	6b	0.8	2b	0.05	0.31
Inferior Temporal Gyrus, posterior division	R	30	30	-0.89	3a	0.79	1a	0.07	0.32	-0.8	8b	0.87	9b	0.05	0.35

Inferior Temporal Gyrus, temporooccipital part	L	31	31	-0.81	10a	0.87	9a	0	0.36	-0.72	6b	0.83	7b	0.05	0.33
Inferior Temporal Gyrus, temporooccipital part	R	32	32	-0.86	3a	0.78	10a	0.05	0.32	-0.88	4b	0.77	4b	0.05	0.34
Postcentral Gyrus	L	33	33	-0.8	3a	0.93	4a	0.03	0.35	-0.81	8b	0.79	2b	0.04	0.32
Postcentral Gyrus	R	34	34	-0.74	4a	0.76	5a	-0.06	0.33	-0.64	2b	0.74	2b	-0.01	0.32
Superior Parietal Lobule	L	35	35	-0.8	5a	0.89	4a	0.03	0.34	-0.82	7b	0.82	1b	0.04	0.37
Superior Parietal Lobule	R	36	36	-0.85	10a	0.92	5a	0.01	0.35	-0.75	6b	0.74	9b	0.03	0.31
Supramarginal Gyrus, anterior division	L	37	37	-0.74	2a	0.8	3a	0	0.34	-0.8	7b	0.79	2b	0.04	0.33
Supramarginal Gyrus, anterior division	R	38	38	-0.88	10a	0.84	1a	0.07	0.34	-0.78	4b	0.75	4b	0	0.34
Supramarginal Gyrus, posterior division	**L**	**39**	**39**	**-0.9**	**3a**	**0.93**	**4a**	**0.11**	**0.34**	**-0.8**	**4b**	**0.9**	**9b**	**0**	**0.38**
Supramarginal Gyrus, posterior division	R	40	40	-0.81	2a	0.8	10a	0.06	0.35	-0.75	6b	0.85	2b	0.02	0.37
Angular Gyrus	L	41	41	-0.78	4a	0.75	5a	0	0.37	-0.82	6b	0.8	7b	0	0.37
Angular Gyrus	R	42	42	-0.82	1a	0.75	7a	0.06	0.35	-0.8	4b	0.81	4b	0	0.33
Lateral Occipital Cortex, superior division	L	43	43	-0.76	1a	0.78	5a	0.06	0.35	-0.82	4b	0.73	8b	0.02	0.34
Lateral Occipital Cortex, superior division	R	44	44	-0.87	3a	0.9	5a	0.05	0.38	-0.92	4b	0.87	9b	-0.01	0.38
Lateral Occipital Cortex, inferior division	L	45	45	-0.95	10a	0.84	5a	0.05	0.33	-0.9	5b	0.83	9b	-0.02	0.34
Lateral Occipital Cortex, inferior division	R	46	46	-0.89	5a	0.9	5a	0.04	0.35	-0.9	4b	0.83	4b	-0.02	0.38
Intracalcarine Cortex	L	47	47	-0.86	10a	0.86	3a	0.05	0.34	-0.8	10b	0.73	4b	0.02	0.32
Intracalcarine Cortex	R	48	48	-0.9	10a	0.83	1a	0.01	0.32	-0.73	6b	0.74	7b	0.02	0.31
Frontal Medial Cortex	L	49	49	-0.89	9a	0.83	10a	0.07	0.31	-0.75	9b	0.75	6b	0.01	0.34

Frontal Medial Cortex	R	50	50	-0.89	5a	0.86	5a	0.02	0.35	-0.87	7b	0.79	8b	0	0.35
Juxtapositional Lobule Cortex (formerly Supplementary Motor Cortex)	L	51	51	-0.85	2a	0.87	2a	0.01	0.35	-0.89	9b	0.79	4b	-0.02	0.35
Juxtapositional Lobule Cortex (formerly Supplementary Motor Cortex)	R	52	52	-0.84	1a	0.78	2a	0	0.34	-0.75	1b	0.7	10b	0.02	0.33
Subcallosal Cortex	L	53	53	-0.81	5a	0.69	4a	0.02	0.32	-0.74	7b	0.67	6b	0.02	0.33
Subcallosal Cortex	R	54	54	-0.83	1a	0.73	5a	0.04	0.32	-0.77	2b	0.75	6b	0.02	0.33
Paracingulate Gyrus	L	55	55	-0.79	10a	0.78	5a	0.02	0.36	-0.77	6b	0.9	7b	0.02	0.33
Paracingulate Gyrus	R	56	56	-0.86	10a	0.82	1a	0.06	0.37	-0.79	8b	0.86	2b	-0.02	0.37
Cingulate Gyrus, anterior division	L	57	57	-0.75	3a	0.83	10a	0.02	0.34	-0.86	9b	0.79	9b	0.03	0.34
Cingulate Gyrus, anterior division	R	58	58	-0.78	5a	0.89	5a	0.08	0.35	-0.81	7b	0.83	7b	0.02	0.3
Cingulate Gyrus, posterior division	L	59	59	-0.84	5a	0.86	5a	0.08	0.33	-0.86	9b	0.85	4b	0.01	0.35
Cingulate Gyrus, posterior division	R	60	60	-0.84	3a	0.84	1a	0.02	0.34	-0.85	6b	0.79	7b	0.02	0.36
Precuneous Cortex	L	61	61	-0.78	5a	0.8	1a	0.02	0.34	-0.76	4b	0.83	7b	0.04	0.34
Precuneous Cortex	R	62	62	-0.84	1a	0.88	10a	-0.01	0.35	-0.84	2b	0.79	9b	0	0.34
Cuneal Cortex	L	63	63	-0.81	9a	0.91	3a	0	0.36	-0.76	2b	0.77	6b	-0.01	0.33
Cuneal Cortex	R	64	64	-0.83	1a	0.91	1a	0.01	0.34	-0.72	6b	0.87	5b	0.03	0.34
Frontal Orbital Cortex	L	65	65	-0.88	1a	0.92	5a	0.02	0.33	-0.76	6b	0.79	4b	-0.04	0.33
Frontal Orbital Cortex	R	66	66	-0.77	1a	0.86	4a	-0.06	0.37	-0.76	9b	0.83	10b	0.04	0.36
Parahippocampal Gyrus, anterior division	L	67	67	-0.8	10a	0.84	4a	0.02	0.34	-0.7	6b	0.85	2b	-0.02	0.33
Parahippocampal Gyrus, anterior division	R	68	68	-0.9	1a	0.76	5a	-0.02	0.34	-0.71	6b	0.74	9b	0.03	0.33
Parahippocampal Gyrus, posterior division	L	69	69	-0.83	3a	0.79	4a	0.01	0.34	-0.91	4b	0.93	4b	-0.02	0.34

Parahippocampal Gyrus, posterior division	R	70	70	-0.83	3a	0.83	4a	-0.01	0.34	-0.81	4b	0.93	4b	-0.01	0.34
Lingual Gyrus	L	71	71	-0.68	6a	0.84	5a	0.03	0.33	-0.76	7b	0.8	2b	0.01	0.32
Lingual Gyrus	R	72	72	-0.85	4a	0.88	4a	0.05	0.34	-0.77	2b	0.8	7b	-0.01	0.35
Temporal Fusiform Cortex, anterior division	L	73	73	-0.9	5a	0.78	1a	-0.01	0.38	-0.77	4b	0.79	3b	-0.01	0.34
Temporal Fusiform Cortex, anterior division	R	74	74	-0.85	5a	0.8	10a	-0.01	0.32	-0.78	9b	0.74	5b	-0.01	0.34
Temporal Fusiform Cortex, posterior division	L	75	75	-0.82	3a	0.86	3a	0.02	0.35	-0.84	4b	0.79	9b	0	0.32
Temporal Fusiform Cortex, posterior division	R	76	76	-0.77	7a	0.87	5a	0	0.37	-0.82	4b	0.82	7b	0.01	0.34
Temporal Occipital Fusiform Cortex	**L**	**77**	**77**	**-0.81**	**3a**	**0.93**	**10a**	**0.15**	**0.35**	**-0.88**	**4b**	**0.86**	**9b**	**0.03**	**0.4**
Temporal Occipital Fusiform Cortex	R	78	78	-0.86	5a	0.86	1a	0.03	0.35	-0.86	4b	0.93	2b	0.01	0.39
Occipital Fusiform Gyrus	L	79	79	-0.89	3a	0.8	5a	0.1	0.35	-0.92	6b	0.88	4b	0.02	0.4
Occipital Fusiform Gyrus	R	80	80	-0.75	5a	0.85	5a	0.01	0.34	-0.87	4b	0.82	10b	-0.03	0.36
Frontal Operculum Cortex	L	81	81	-0.76	9a	0.81	1a	0	0.34	-0.83	3b	0.76	7b	-0.05	0.36
Frontal Operculum Cortex	R	82	82	-0.8	1a	0.77	4a	-0.03	0.33	-0.75	4b	0.79	2b	0.02	0.29
Central Opercular Cortex	L	83	83	-0.84	7a	0.84	1a	-0.06	0.35	-0.77	8b	0.83	9b	0.01	0.34
Central Opercular Cortex	R	84	84	-0.75	5a	0.87	1a	-0.02	0.36	-0.71	4b	0.75	7b	-0.01	0.34
Parietal Operculum Cortex	L	85	85	-0.79	3a	0.84	9a	-0.04	0.34	-0.84	9b	0.91	4b	0.01	0.35
Parietal Operculum Cortex	R	86	86	-0.74	3a	0.8	5a	-0.03	0.36	-0.73	9b	0.85	7b	0.02	0.33
Planum Polare	L	87	87	-0.81	1a	0.8	1a	-0.02	0.36	-0.87	4b	0.85	3b	-0.01	0.38
Planum Polare	R	88	88	-0.67	10a	0.83	4a	0.02	0.37	-0.84	8b	0.88	8b	-0.02	0.38
Heschl's Gyrus (includes H1 and H2)	L	89	89	-0.73	9a	0.88	1a	-0.01	0.36	-0.79	6b	0.77	2b	-0.03	0.34
Heschl's Gyrus (includes H1 and H2)	R	90	90	-0.79	5a	0.83	1a	0	0.36	-0.87	8b	0.82	8b	-0.03	0.35

Planum Temporale	L	91	91	-0.69	5a	0.89	7a	0.02	0.39	-0.85	7b	0.85	8b	-0.02	0.39
Planum Temporale	R	92	92	-0.71	6a	0.88	7a	0	0.38	-0.86	8b	0.83	8b	0	0.39
Supracalcarine Cortex	L	93	93	-0.76	4a	0.86	9a	0.04	0.36	-0.87	4b	0.78	6b	0.02	0.32
Supracalcarine Cortex	R	94	94	-0.77	1a	0.84	10a	0.02	0.34	-0.86	4b	0.73	6b	0	0.33
Occipital Pole	L	95	95	-0.82	10a	0.86	1a	0.08	0.37	-0.81	4b	0.83	9b	0.01	0.39
Occipital Pole	R	96	96	-0.78	3a	0.86	1a	0.05	0.37	-0.87	9b	0.88	7b	0.01	0.39
Subcortical Sites															
Thalamus	L	4	97	-0.79	1a	0.82	10a	0.04	0.33	-0.86	6b	0.72	9b	0.01	0.33
Caudate	L	5	98	-0.66	1a	0.83	10a	0.06	0.31	-0.71	4b	0.79	4b	0.01	0.32
Putamen	L	6	99	-0.92	10a	0.92	1a	-0.02	0.37	-0.8	8b	0.87	6b	-0.03	0.36
Pallidum	L	7	100	-0.84	9a	0.79	1a	-0.04	0.34	-0.77	6b	0.85	4b	0	0.33
Brain-Stem		8	101	-0.85	5a	0.8	5a	0	0.32	-0.65	7b	0.88	8b	-0.01	0.32
Hippocampus	L	9	102	-0.76	5a	0.79	3a	0.02	0.3	-0.76	6b	0.86	3b	-0.02	0.32
Amygdala	L	10	103	-0.9	1a	0.84	5a	0.02	0.34	-0.75	9b	0.72	10b	-0.01	0.35
Accumbens	L	11	104	-0.7	2a	0.87	1a	0.03	0.34	-0.91	2b	0.78	6b	0.05	0.35
Thalamus	R	15	105	-0.85	10a	0.82	6a	-0.03	0.35	-0.64	4b	0.85	7b	0	0.33
Caudate	R	16	106	-0.87	10a	0.82	1a	-0.03	0.36	-0.72	6b	0.87	9b	0.01	0.3
Putamen	R	17	107	-0.79	10a	0.84	1a	0.02	0.31	-0.68	2b	0.76	2b	0.01	0.31
Pallidum	R	18	108	-0.76	5a	0.69	3a	-0.04	0.31	-0.65	9b	0.74	4b	0.01	0.31
Hippocampus	R	19	109	-0.74	1a	0.78	10a	0.01	0.3	-0.74	3b	0.84	9b	0.03	0.36
Amygdala	R	20	110	-0.87	1a	0.82	1a	0.01	0.37	-0.83	3b	0.81	8b	0.01	0.32
Accumbens	R	21	111	-0.78	1a	0.76	1a	-0.01	0.36	-0.92	4b	0.75	8b	0.02	0.34

Appendix Figure 1: Further Elaboration of CBC

To calculate CBC for a single subject and a single pitch we used the following set of steps (see illustration): First, we pre-processed the data to remove artifacts, and clean ghost imagery. Following, we normalized all voxels to the same range of BOLD signal (1). These steps are standard fMRI pre-processing steps that are done, typically, using the acquisition software or existing toolboxes. Following, we co-registered all brains to the same coordinates using Talairach coordinates (2). This ensures that all voxels are reflecting the same brain structure. After the co-registering we looked at each ROI and selected the samples that pertain to a specific pitch (in the illustration, pitch #6) (3). We then correlated all the samples, voxel-by-voxel, for the specific ROI and correlated the time series, averaging all the correlations within the ROI to a single number (4). We repeated this step for all 111 ROIs for a pair of subjects (5). This yields a single CBC value for the subject pair. We repeated these steps for all pairs of subjects who watched the same pitch. To compute the CBC for subject 1, for example, we then averaged all the pairs that included subject 1 and the specific pitch. This accounts for the subject|pitch value.