Capturing passion expressed in text with artificial intelligence (AI): Affective passion waned, and identity centrality was sustained in social ventures

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Capturing passion expressed in text with artificial intelligence (AI): Affective passion waned, and identity centrality was sustained in social ventures

Abstract

Entrepreneurial passion can influence individual well-being and improve firm-level outcomes, yet little is known about how to rapidly detect a change in passion from entrepreneurs' communication. We draw on advancements in both the passion literature and artificial intelligence (AI) methods, to capture entrepreneurial passion expressed for founding a venture at different points in time. Specifically, we developed an AI algorithm to recognize identity-based passion (identity centrality) from training data, comprised of eight hours of transcribed interviews with entrepreneurs (achieving 84% accuracy), and detect affective passion (intense positive feelings) with sentiment analysis. Application of these two novel measurement approaches, to longitudinal interview text with early-stage entrepreneurs (N=11, two time periods) in a six-month social venture accelerator, indicate that intense positive feelings decline while identity centrality varies. We conclude by outlining opportunities for future research.

1. Introduction

The rapid expansion in the area of inquiry related to entrepreneurial passion—defined as the "consciously accessible, intense positive feelings experienced by engagement in entrepreneurial activities associated with roles that are meaningful and salient to the self-identity of the entrepreneur" (Cardon, Wincent, Singh, & Drnovsek, 2009, p. 515)—has provided crucial insights that inform both theory and practice (Newman, Obschonka, Moeller, & Chandan, 2019; Pollack, Ho, O'Boyle, & Kirkman, 2020). However, despite the remarkable growth in the academic field here, there is much we do not yet know.

Two recent reviews of the literature lament that we, as researchers, know very little about the specific area of how passion changes over time. Pollack et al. (2020), in their meta-analysis, note that from the extant literature they, "…could not reveal insights related to how passion develops, changes in time, and is either amplified or attenuated at work" (Pollack, Ho, O'Boyle, & Kirkman, 2020, p. 325). Moreover, in their narrative review, Newman et al. (2019, p. 32) shared that, overall, "…limited research has examined whether and how entrepreneurial passion develops over time….". Regarding this topic—passion change over time—what limited findings do exist, show support for the premise that passion can indeed change. For example, Collewaert et al. (2016) illustrated that passion for founding did change over the life of a venture with identity centrality remaining stable while intense positive feelings for founding lessened over time. Future studies in *traditional* entrepreneurship settings would be expected to yield similar results to what Collewaert et al. (2016) found.

However, in a *social* entrepreneurship context, the "emotional payback" from prosocial behavior may cause the affective element of passion to increase (Yitshaki & Kropp, 2016). This is intriguing because it presents a theoretical conundrum regarding whether passion wains or is sustained and gained in the context of social entrepreneurship—a context not yet widely studied

with regard to passion. This is important to consider, in light of emerging work that shows that there are recursive effects of passion on entrepreneurial self-efficacy and performance (Lex, Gielnik, Spitzmuller, Jacob, & Frese, 2020). This lacuna in the literature is where we focus our efforts in the present research.

We aim to extend the burgeoning area of inquiry on passion to the social entrepreneurship context, through the use of artificial intelligence (AI) on unstructured text data. Regarding unstructured text data, individuals' experiences are commonly recorded in an ongoing manner in the format of, as examples, interviews, podcasts, emails, blogs, social media posts. These unstructured data record first-hand experiences, as they happen, in an ongoing manner, which means that "…everyday lives can be captured" and studied in "real-time" (Peters, Marrero, & Gosling, 2021, p. 1). Unstructured text data form approximately 80% of all data, and this percentage is rapidly growing (Dayley & Logan, 2015). Such increasingly accessible and interesting data sources may harbor new insights into entrepreneurial phenomena. However, entrepreneurial passion (like many other entrepreneurial phenomena) is too complex to study from unstructured data using traditional quantitative approaches.

To advance this area of inquiry, we developed an AI algorithm to recognize identity-based passion (identity centrality), as well as to detect affective passion (intense positive feelings) with sentiment analysis. We approach the present work with the following, open-ended, research question: *How does entrepreneurial passion—identity centrality and affective passion—for founding a social venture change over time?* We proceed as follows. First, we outline our methodological approach, and then, we present the findings of our work. And, in conclusion, we discuss the theoretical, methodological, and practical implications of our findings as well as outline multiple areas for future research.

2. Methods

2.1 Sample and Procedures

The data for the present research were collected from the lead entrepreneurs of eleven social ventures engaged in one cohort of a non-residential accelerator program. Semi-structured interviews were used to collect data at the beginning (month 1), in the middle (month 3), and completion of the accelerator program (month 7). We use data from the beginning (*Time* 1) and the end (*Time* 2) to model change in passion. In these interviews, participants were instructed to sequentially reflect on and share their feelings about their current (i) product or service, (ii) market, (iii) business model, and then (iv) team experience. The interviews were recorded, transcribed, and then shared with participants to ensure accuracy. Our data collection process with these participants resulted in over 15 hours of transcribed interviews that composed roughly 230 pages of single-spaced text. With this amount of text, we looked to best practices in the literature to aid our organization and analysis of these data.

2.2 Capturing Passion with AI

New methods in artificial intelligence allow scholars to rapidly detect psychological signals and mental states from linguistic clues. AI is a computation approach defined by its ability to interpret communication data, "to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" (Kaplan & Haenlein, 2019, p. 17), which includes making psychological inferences from human narratives. Accordingly, we pilot an AI to detect expressed passion from communication, and in turn, study entrepreneurial passion in a contemporary context at different points in time. Our approach, as this is a novel method, examines passion in our sample of social entrepreneurs retrospectively—i.e., we did not analyze our data in real time. However, we surmise that our efforts bring us one step closer to using AI in real-time for analyses of unstructured communication data—a data source that has been propelled forward with the digitalization of communication (e.g., the experiences of

entrepreneurs are now reflected in recorded meetings and interviews, at rates never seen before). For an overview of how our approach relates to current methods of measuring entrepreneurial passion, see the Appendix.

Development of passion algorithms. For an AI algorithm to be effective at recognizing patterns in text, it requires examples from which it can learn (Athey & Imbens, 2019). We provided an algorithm with 649 training examples, by labeling data as containing identity centrality (e.g., "I am a social entrepreneur, I am not in it to become a millionaire really") or not (e.g., "It is a completely different thing to run a social enterprise"). The training set was informed by coding employed by Cardon, Glauser, and Murnieks (2017) and built from eight transcribed private one-hour-long interviews with social venture team leaders (different ones than our sample), and augmented with identity centrality items listed in Cardon et al. (2013). We balanced the dataset, so that the 347 sentences that depict identity centrality statements, were the same in number (i.e., 347) to sentences that did not, to give equal probability to either choice in the algorithm.

Once we had our training data set, we translated sentences into meaningful numeric representations. We assigned numbers to words based on their general proximity to other words in the English language – this is a cutting-edge approach called word-embeddings (Garg, Schiebinger, Jurafsky, & Zou, 2018; Kozlowski, Taddy, & Evans, 2019). The exact numbers assigned to each word were based on billions of previously mapped data points from BERT's pre-trained word embeddings, which we programmed with Python (Peters et al., 2018) and TensorFlow (Abadi et al., 2016). Specifically, we used DistilBERT from the Hugging Face Transformers library to establish the sentence embeddings (dimensions: 768), then employed basic deep pre-trained neural network architecture with dense and dropout layers for training and classification (Sanh, Debut, Chaumond, & Wolf, 2019). We used pre-trained word embeddings

because it is a revolutionarily nuanced technique that allows researchers to detect meaning (i.e., in our case, identity centrality) in sentences that are contextually similar to the training set, even if the exact words differ. Overall, testing these training data with a hold-out set representing 10% of the data demonstrated excellent accuracy (accuracy: 84%, identity recall: 87%, harmonic mean: 85%). See Table 1 for an example of identity-relevant words produced from the training-data.

In the case of the affective element of passion, there were plentiful data sources and pre-trained algorithms for detecting intense positive feelings (Pang & Lee, 2008). We trialed five different tools for accuracy at correctly detecting intensive positive sentences from established entrepreneurial passion measures (Cardon et al., 2013), and ultimately gained the best performance from IBM Watson's Tone Analyzer tool, with Joyfulness values above 0.7. These measures of identity passion and affective passion were applied to our longitudinal research data, and further tested for robustness (see the Appendix for further details).

3. Results

3.1 Overview

AI allowed us to uncover elements of passion not easily discoverable using traditional methods. By employing AI, we captured both dimensions of passion from text, emphasized in foundational entrepreneurial passion research (Cardon et al., 2009): identity centrality as well as affective passion. Identity centrality is a linguistically complex construct, that we would not have been able to measure with established text analysis techniques, such as dictionary methods (as they are "still quite crude"; Tausczik & Pennebaker, 2010, p. 30). Unlike these techniques, AI can quickly model complex relationships. Our AI algorithm understood how words were related to each other (it was built with pre-trained word embeddings), so passion was detected in a wide variety of terms and phrases. Furthermore, deviating from qualitative approaches, using AI

allowed us to quickly measure and quantitatively compare expressed passion at two different points in time. While questionnaires can be used to quantify entrepreneurial passion quickly, their time-horizons are often limited when employed post hoc (e.g., difficulty recalling passion from a specific period), and sometimes they cannot be employed retrospectively without the introduction of bias from present-day events (e.g., hindsight bias) or moods (e.g., mood congruence effect). Our AI approach, on the other hand, enables us to measure passion from text effectively and efficiently—we did this retrospectively as a pilot test. Overall, our approach reveals a viable new path for studying entrepreneurial passion from complex linguistic patterns in real-time. In summary, our successful AI-based measurement of passion retrospectively can facilitate new work moving forward that rapidly quantifies passion in real-time from the subtitles of entrepreneurs' communication.

3.2 Change Over Time

We assessed if the change in identity and affective passion was significantly different over time. To do this, we examined passion at the beginning and end of the sampling period, using a non-parametric Wilcoxon signed-rank test. To aid in the interpretability of results we estimated one missing observation with similar response pattern-matching imputation. We found a consistent pattern of results whether it was included or excluded (Enders & Bandalos, 2001).

Descriptive statistics are shown in Table 2. As illustrated in Figure 1, affective passion declined. The decline in affective passion between the earlier (Mdn = 8.92) and later (Mdn = 3.00) time points was statistically significant; V = 66, p = < .001, r = .99. Change in identity passion, was not statistically significant between the earlier (Mdn = 8.60) and later (Mdn = 10.19) time points; V = 37, p = 0.76, r = .99.

[Insert Tables 1 and 2, and Figures 1 and 2 About Here]

Interestingly, our AI-derived measures of identity passion and affective passion often moved in opposite directions in time. Intense positive feelings significantly reduced, while identity centrality remained the same, or in some cases, increased (e.g., Teams A, E, and K in Figure 1). While entrepreneurs expressed fewer intense positive feelings after spending more time developing their ventures, their communication provided clues to suggest the venture was still central to their identity. Put another way, text-based AI revealed a loss of affective passion, yet sustained identity passion among social entrepreneurs in time.

3.2.3 Language Changes

We further explored how passion changed, by examining the similarities and differences in the language used to express it[1]. To do this, we compared the top keywords employed by our AI. These top keywords (illustrated in Figure 2) are terms common in sentences that expressed identity passion in Time 1 and Time 2 respectively, and yet were simultaneously rare in the pooled corpus of text (a technique called term frequency-inverse document frequency vectors, see: Lane, Hapke & Howard, 2019).

There were some consistencies in language over time, such that 12 of the 25 top keywords were shared between the two sets of interviews (the overlapping area in Figure 2). These terms represent the enduring language participants utilized, to express their social entrepreneur identity, such as, “impact”, “want”, “feel”, “part”, and “people”. Not all top keywords were similar over time, which is interesting for highlighting the differences in the data. Among the top terms in Time 1, were those related to excitement and uncertainty, such as “expectations”, “opportunity”, and “goal” (the left side of Figure 2). These words often depict the positive sentiments entrepreneurs felt at the beginning.

[1] We thank the Editor for this useful suggestion.

In Time 2 these hopeful top keywords were superseded with certain, yet far less rosy terms, that highlight the challenges entrepreneurs encountered along their journey (the right side of Figure 2). For instance, entrepreneurs transmitted the complexity involved in developing their social ventures, through words such as “hard” and “big” (social entrepreneurs often rely on an intricate array of social partners to address ‘wicked problems’ with no easy solutions; see Renko, 2013 for a thoughtful discussion). And, they reflected on the importance of their “values” when engaging in the commercial “game”, in the pursuit of economic viability. Overall, in context these Time 2 keywords often relate to the concessions social entrepreneurs felt they had to make in early-stage entrepreneurship. Our data thus suggest that these social venture challenges could sometimes hamper the entrepreneurs’ abilities to autonomously enact their ideas, which coincides with their loss of positive feelings.

Despite the loss of positive feelings, participants continued to express their social entrepreneur identity. As an entrepreneur from our study explained, participants felt committed to their identity and role through these challenges: “I wouldn't have done all this if I didn't want to make a difference because it has been very hard.” Therefore, we, intriguingly, illustrate that the affective and identity centrality dimensions of passion had different trajectories over time in the domain of social entrepreneurship.

4. Discussion

Our cutting-edge AI-based approach, enabled us to examine entrepreneurial passion for founding a social venture using transcribed multi-wave interview data from the lead entrepreneurs of eleven social venture teams. This approach provided insight into how passion changed across two points in time, and our findings support the inference that the affective dimension of passion wains with time, while the degree of change in the identity centrality element of passion is variable.

4.1. Theoretical and Methodological Implications

Our findings contribute important insights into the direction of temporal variability in the early stages of founding a social venture (Collewaert et al., 2016; Gielnik, Spitzmuller, Schmitt, Klemann, & Frese, 2014; Stroe, Wincent, & Parida, 2018). While Yitshaki and Kropp (2016) find that the affective element of passion increases, our findings support Collewaert et al. (2016) in that the affective element of passion declines, while the identity aspect of passion remains stable. Put differently, our findings provide a conceptual replication of previous work—i.e., Collewaert et al. (2016)—that occurs in a new context (social entrepreneurship) and uses a novel analytical approach that could help break new ground in the field.

Previous findings touching on this topic solely relate to commercial entrepreneurs in the early stages of founding a venture. Indeed, the literature on early-stage social ventures is primarily focused on positive aspects of social entrepreneurs (Peredo & McLean, 2006). We show that the emphasis on the positive side of social entrepreneurship might not be reflective of the lived experience of social entrepreneurs themselves, if their affective passion wains in time. The challenges associated with addressing (often complex) social issues while balancing economic objectives (Renko, 2013) may limit autonomous action, and in turn, dampen positive feelings (in line with self-determination theory: Ryan & Deci, 2017). This provides an initial answer to the lacuna of whether, and how, passion changes over time in social ventures and, additionally, this finding offers empirical evidence to reveal the less positive aspects of being a social entrepreneur, an area that is largely neglected in the literature (Bolino & Grant, 2016).

Furthermore, regarding the lack of context-specific, theoretically-driven, inquiry into passion in the literature, we illustrate the changeable nature of passion in the specific context of social entrepreneurship. Our sample of social entrepreneurs in an accelerator provides a unique context to respond to calls to consider the heterogeneity amongst entrepreneurs (Davidsson,

2016) and develop more context-sensitive conceptualizations and measures (Stephan, 2018; Wiklund, Nikolaev, Shir, Foo, & Bradley, 2019). Social ventures pursue social objectives and strive to implement social change (Gupta, Chauhan, Paul, & Jaiswal, 2020). Although scholars have called for a more thorough investigation into the nature of domain-specific passion and, in particular, passion relevant to social ventures (Cardon, Glauser, et al., 2017; Ko, Liu, Wan Yusoff, & Che Mat, 2019), scholarly inquiry has rarely examined change in passion in social ventures. This is non-trivial as passion is important for creating greater social value (Thorgren & Omorede, 2018) and is, thus, vital for sustaining action in a social venture. While entrepreneurial passion could be conceived of as relatively stable over time (Cardon et al., 2013; Obschonka, Moeller, & Goethner, 2019), our work—although exploratory—highlights that passion is *also* temporally variable in the early stages of founding a social venture, and that there are differential changes in the affective and identity dimensions of passion for founding a social venture.

Our findings also advance the empirical side of passion research by introducing a measurement approach to 'expressed passion.' Put succinctly, rich data produced by entrepreneurs are often in unstructured text format (e.g., social media, emails, blog updates) and measures used to date cannot be rapidly applied to such a task. While scholars have made great advances by measuring others' perceptions of displayed affective passion from visual presentations (Chen et al., 2009; Davis, Hmieleski, Webb, & Coombs, 2017), recent research highlights the need to (a) capture entrepreneurial phenomena via text (Short, McKenny, & Reid, 2018), and to (b) include the identity element of passion in measures of external manifestations of passion (Mitteness et al., 2012; Murnieks, Mosakowski, & Cardon, 2014). Yet, identity is difficult to measure with traditional analytical techniques (e.g., computer-aided text analysis, CATA). By building on efforts to generate insights from narrative text data (Moss, Renko, Block, & Meyskens, 2018), and responding to calls to detect entrepreneurial identity using

advanced techniques (Oo et al., 2019), we develop the first computerized approach for capturing 'expressed' passion in text.

This approach allows us to capture both identity and affective elements of passion from entrepreneurs' use of language. Thus, we pave the way for researchers and practitioners to improve this technique and catch changes in passion "as it happens" (Brundin, 2007, p. 282), as well as to more efficiently look at passion retrospectively by efficiently examining past communications. Put simply, our exploratory measurement approach to expressed passion demonstrates that natural language processing of text data has the capability to shed light on complex entrepreneurial processes and advance the practice of entrepreneurship in various contexts. From a practical perspective, for example, a natural language processing approach could be used by investors to evaluate firms in which they are considering funding, or used by accelerators for selection and progress monitoring of entrepreneurs. And, this could also be used in academic settings (e.g., entrepreneurship programs) to train and evaluate prospective entrepreneurs.

4.2 Limitations and Additional Directions for Future Research

We note the following limitations and associated opportunities for future research. First, with regards to our data and measurement approaches to identity centrality, and affective passion, the novel development, and deployment of what we did in this study make it exploratory in nature. More specifically, and regarding context, we conducted our work in conjunction with a social venture accelerator using interview-based data. Future work should explore AI-based approaches with individuals who do not identify as social entrepreneurs using myriad sources of unstructured data.

Second, we did engage in vigorous reliability testing with our measurement approach (outlined in the appendix)—and, we found a high prevalence of false positives, which required

manual correction. So, future work is encouraged to, via replication, adapt and advance approaches towards measuring entrepreneurial passion with AI. Here, future work that improves approaches of measuring passion can enable scholars to unobtrusively examine passion in a range of contexts that would otherwise be difficult to observe. Here, natural language processing has great potential as a tool for avoiding biases and limitations of traditional measures that rely on post hoc assessment.

Regarding additional directions for future research, Table 3 outlines multiple exciting new avenues for passion research that AI makes possible. Using AI allows researchers to go beyond self-reported measures of passion and use more situated data in the form of narrated text. We no longer are required to rely solely on participants reporting how their passion has changed at different points in time, but can infer the changes as a result of changes in their narratives. Here, AI has the potential to reduce the burden on participants and researchers, and greatly improve the detection of passion from narrative text on novel and historical data sources.

[Insert Table 3 About Here]

4.3 Conclusion

We illustrate that passion for founding a social venture is temporally variable. Specifically, while we observed that the affective dimension of passion significantly declines, the change in the identity centrality dimension of passion is variable. Overall, we reveal nuanced insights into the passion literature through the cutting-edge use of AI-based text analyses. We hope that our work affords an ample foundation for future research—in passion and using AI—that is both theory-focused and practically useful.

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Table 1: Top words related to identity passion for a social venture found in data

Identity passion: Top words		
people	community	disabilities
social	founder	children
business	work	understand
enterprise	employers	solutions
disabled	problems	kind
want	make	better
support	growing	help

Note. Words identified via a TF-IDF weighting on the training data. Words that appeared in 85% of other non-identity sentences were ignored to create this word-list unique to identity passion.

Table 2: Descriptive statistics and correlations for study variables

Variables	*Mean*	*SD*	Min	Max	1	2	3	4
1. Affective-p, t1	12.01	6.85	5.33	29.03				
2. Affective-p, t2	4.02	4.08	0.00	13.00	0.26			
3. Identity-p, t1	8.22	3.53	0.23	13.54	-0.53	-0.24		
4. Identity-p, t2	8.76	3.80	2.56	14.36	0.15	0.44	-0.05	-

Note: N = 11. These symbols †, *, ** denote significance at the .10, .05, and <.01 levels.

Table 3: New pathways for examining entrepreneurial passion with artificial intelligence

Research Question	Artificial Intelligence Approach
When and how does passion spread?	Explore expressed passion contagion effects within teams, and beyond (e.g., work-family spillover) by examining interpersonal communication. Research exploring this topic could measure expressed passion from multiple data sources such as written information flow (e.g., emails), face to face communication (e.g., sociometric badges and other wearable devices; Taylor, Freeman, Olguin Olguin, & Kim, 2016; Waber et al., 2011), and online interactions (e.g., Twitter). Particularly interesting research would explore how passion spreads at a societal level (e.g., akin to collective optimism, but towards a venture; Anglin, McKenny, & Short, 2018). For example, by examining expressed passion in social media, researchers could model how passion for a social enterprise spreads through social channels (e.g., the public sharing intense positive feelings and identity centrality with a firm's social mission) and develops geographically (e.g., Obschonka et al., 2018).
What influence does expressed, displayed, and felt passion homogeneity or heterogeneity have on performance?	Model interactions between felt, expressed, and displayed passion, to explore when differences are complementary or conflicting (Blok & Pedersen, 2014), and the differential impacts it produces for individual and firm-level outcomes (e.g., how pitches are judged; Cardon, Mitteness, et al., 2017). For example, strong differences from expressed and displayed passion to felt passion (passion manifestation heterogeneity) may signal the presence of surface acting. With artificial intelligence, researchers could model the long term (e.g., "fake it 'till you make it?") and short term influence of such behavior on physiological function (e.g., heart rate variability, skin conductance) and wellbeing (e.g., Grandey, Rupp, & Brice, 2015; Van Kleef, Homan, & Cheshin, 2012).
How does expressed entrepreneurial passion differ between cultures?	Compare differences in how entrepreneurial passion is expressed and interpreted in collectivist and individualistic cultures (e.g., Yang, Zhou, & Zhang, 2015). By leveraging the power of artificial intelligence illustrated in the current article, scholars can inductively capture (data-driven) the unique ways passion is expressed (e.g., Tata, Martinez, Garcia, Oesch, & Brusoni, 2017) and compare common themes across languages (using state of the art translation packages) and regions. It is possible that passion may manifest in different and interesting ways, such as with greater expressiveness in some contexts (e.g., vocabulary, time communicating with others about the venture).
What influence does entrepreneurial passion have on behavior, and vice versa?	Capture cross-directional effects between daily expressed passion, and time use (e.g., cyberloafing), social interactions and communication styles (e.g., vocabulary), and innovative behavior in the firm (e.g., Williamson, Battisti, Leatherbee, & Gish, 2019). Spillover effects from different life domains would be particularly interesting to examine

	through this lens. For example, do passionate interactions with a significant other contribute to or take away from passion expressed the next day in the venture (e.g., Leavitt, Barnes, Watkins, & Wagner, 2019)? Researchers could infer such interactions by modeling unobtrusive data, such as geotagging and specialty sensor data (e.g., wearable devices, and interaction detection).
How does entrepreneurial passion intensity and focus influence entrepreneurial decision-making and heuristics?	Use artificial intelligence to model entrepreneurial decision-making in real-time, through observable behavior (e.g., Townsend & Hunt, 2019), and examine the role of expressed passion on these processes. For example, are periods with higher expressed passion related to dynamic shifts in goal-directed activity and stable changes in resources, or static goals and the acquisition of new resources (e.g., effectuation versus causation; Sarasvathy, 2001)?
How do individual passion profiles relate to entrepreneurial outcomes?	Construct entrepreneurial passion profiles from machine learning techniques (e.g., Harrison, Thurgood, Boivie, & Pfarrer, 2019), considering all potential combinations of entrepreneurial focus (e.g., passion for a social enterprise, passion for founding, etc.) and intensity. Examine which passion profiles relate to success at different entrepreneurial milestones, such as gaining funding (e.g., Anglin, Wolfe, Short, McKenny, & Pidduck, 2018) and firm growth trajectories (e.g., modeled using machine learning algorithms van Witteloostuijn & Kolkman, 2019).
How do team passion profiles relate to entrepreneurial outcomes?	Model variation in passion intensity and type in teams (Santos & Cardon, 2019) through the dynamic detection of expressed passion, and model the complex impact different team configurations have on team performance and longevity. Research that considers interpersonal communication patterns (e.g., via wearable sensors; Olguín Olguín, Gloor, & Pentland, 2009) would be poised to make a valuable contribution to this end (e.g., Boone, Andries, & Clarysse, 2019). Studying the nuances of human interactions this way could lead to important observations, both theoretically focused and practically useful (e.g., H. Peters et al., 2021).

Figure 1: Change in passion expressed in words

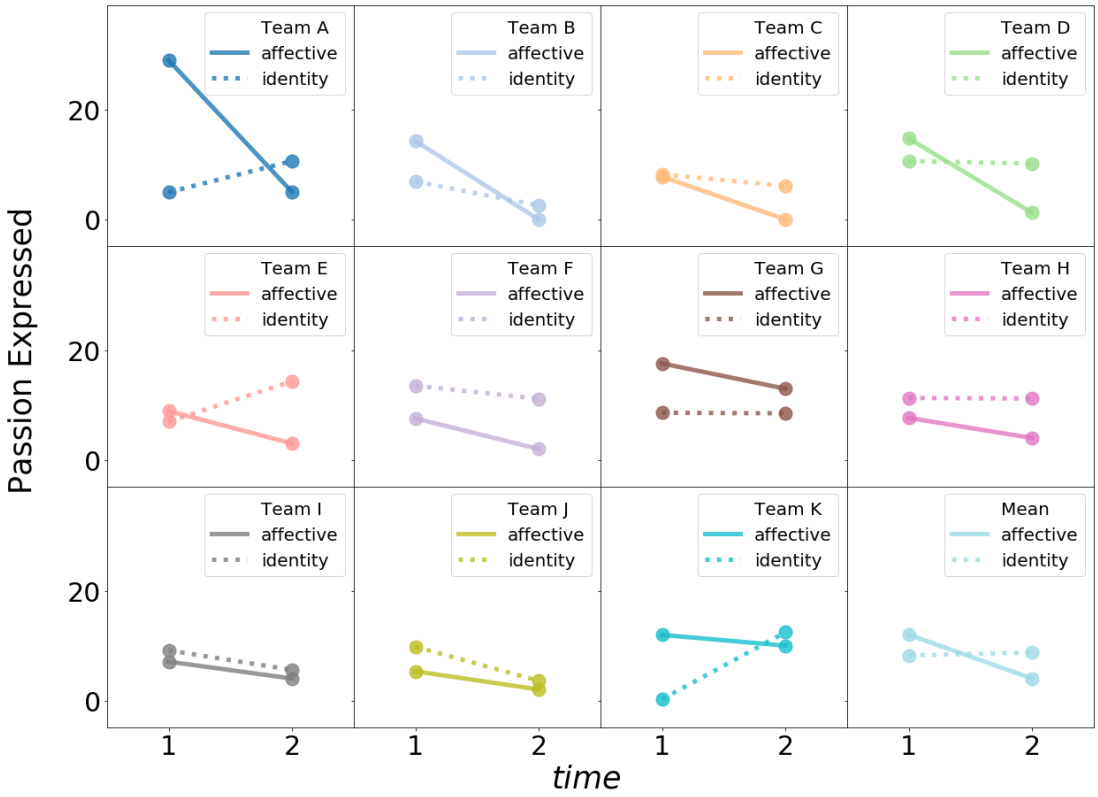
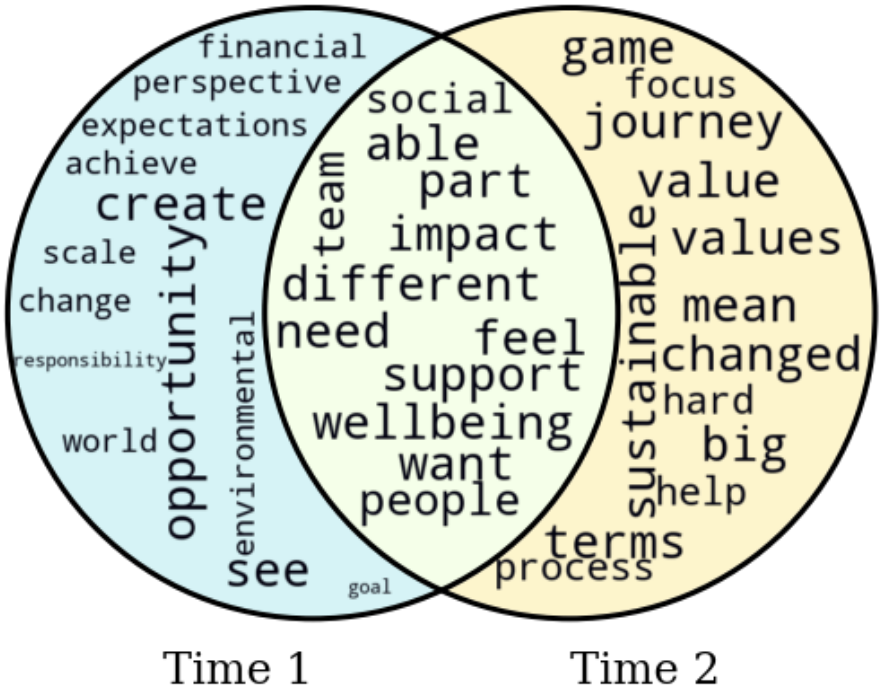


Figure 2: Shifts in social entrepreneurs' keywords between the first and final interviews



Appendix: Methodological Procedure

Methods of Measuring Entrepreneurial Passion

Artificial intelligence can capture psychological constructs from subtleties in human expression. This enables researchers to employ open-ended natural expressions ("I am feeling extremely positive about the business!"), instead of closed-ended responses, such as number scales (e.g., 7 - "Always"; Kjell, Kjell, Garcia, & Sikström, 2019) to study human behavior. The high efficacy of AI on text data has allowed practitioners to measure the psychological states and dispositions of people based on their communication alone (Arslan, Schilling, Gerlach, & Penke, 2018; Kern et al., 2016; Williamson, et al., 2020). Despite the effectiveness of AI in other domains, and even though there is a growing scholarly appetite for measuring entrepreneurial passion in a wide range of ways (see Appendix 1a and 1b for examples), AI has not been used to explore changes in the passion of entrepreneurs over time. AI, we believe, is an optimal approach as it can infer entrepreneurial passion from subtle linguistic signals in a rapid, and unobtrusive manner, and thus can highlight how passion changes when modeled on communication over different time periods.

Early work indicates that entrepreneurial passion can not only be measured via self-reported questionaries (see Appendix 1a: "felt passion"), but can indeed be detected by others (see "displayed passion"). As outlined in Appendix 1b, passion has been inferred from entrepreneurs' presentations and pitches, as well as interpersonal communication. This highlights the appetite for measuring passion in diverse ways, and the feasibility to detect it. Yet passion has rarely been captured in text (see Appendix 1a: "expressed passion"). In inductive research using human intelligence, Cardon, Glauser, and Murnieks (2017) identified different sources of entrepreneurial passion from transcribed interview data, using sentences that reflected an

entrepreneur's identity centrality and affective passion. While the exact *words* entrepreneurs used to express identity and affective passion in their interviews varied (e.g., from "we wanted to make the world a little better place" to "my goal is to scale this immensely", p. 27), the expressions could be identified using human intelligence because they shared common meanings and linguistic patterns. However, recognizing similarities and complex patterns in text data can be costly for humans, and impractical with computational text analysis methods with dictionary approaches—luckily this is a strength of AI. We follow the trail that Cardon, Glauser, and Murnieks (2017) blazed—capturing passion in text from interview data—and we pilot an approach to rapidly measuring passion by detecting it from complex patterns in text data with AI while also comparing passion at different points in time.

Appendix 1a: Forms of measuring entrepreneurial passion: A conceptual framework

Manifestation	Internal manifestation *"Felt passion"*	External manifestation *"Displayed passion"*	External manifestation *"Expressed passion"*
Detection	Subjective feelings that are cognitively interpreted by the entrepreneur.	Signals of passion via physiological factors (e.g., gestures, facial expressions, voice) and communication.	Linguistic factors that signal intense positive feelings and identity centrality ("identity passion") components of passion.
Identified by	Self: self-reported.	Other: perceived by external observers.	Other: perceived by algorithms.
Affective	Yes	Yes	Yes
Identity	Yes	No	Yes
Example	Cardon et al., (2013)	Chen, Yao, & Kotha (2009) Li, Chen, Kotha & Fisher (2017).	**The current article**: A computerized textual AI approach. Related to qualitative hand-coded research by Cardon, Glauser & Murnieks (2017).

Note: Affective = the affective element of passion, also known as intense positive feelings. Identity = the identity element of passion, or identity centrality. Perceived passion is grouped with displayed passion, as it is also based on an external observer's evaluation of passion.

Appendix 1b: How externally manifested passion has been measured until now

Authors	Measure of passion	Medium of displayed passion
Chen, Yao, & Kotha (2009).	Developed an 11-item "perceived passion" scale (and a 6-item subscale) relating to body movements, gestures, facial expressions, voice, the content of a presentation, and communication. E.g., "the presenter(s) used a lot of gestures."	Business plan competition performances.
Breugst, Domurath, Patzelt, & Klaukien (2012).	Developed a measure of perceived passion for founding, inventing, and developing, guided by Cardon et al., (2009). E.g., "the entrepreneur seems to be excited to figure out new ways to solve unmet market needs that can be commercialized."	Employee's interactions with the founder of the firm.
Mitteness, Sudek, & Cardon (2012).	Developed a measure of perceived passion with two items: "The CEO is passionate about the company" and "The CEO is very enthusiastic."	Entrepreneurs' presentations.
Galbraith, Denoble, Ehrlich, & Horowitz (2013).	Employed an 11-item "perceived passion" scale developed by Chen et al. (2009).	Entrepreneurs' presentations.
Cardon, Glauser, & Murnieks (2017).	Undertook a holistic assessment of passion from text, guided by the use of words "passion", "love", "excitement", and "who or what I am."	Text from interviews.
Davis, Hmieleski, Webb, & Coombs (2017).	Employed a six-item scale of "affective passion" developed by Chen et al. (2009).	Product pitches by entrepreneurs.
Li, Chen, Kotha, & Fisher (2017).	Developed a six-item scale of "displayed entrepreneurial passion" by integrating and modifying items developed by Chen et al. (2009). E.g., "appears excited about the project idea."	Crowdfunding videos.
Moore & Wang (2018).	Employed a six-item "displayed passion" scale adapted from Chen et al. (2009). E.g., "Mentor had rich communication", "Mentor was energetic."	Interaction between executives and mentors.
Oo, Allison, Sahaym, & Juasrikul (2019).	Employed a six-item "displayed passion" scale developed by Chen et al. (2009), and a two-item scale adapted from Mitteness et al. (2012).	Crowdfunding pitches.
Shane, Drover, Clingingsmith, & Cerf (in-press).	Employed a six-item scale by Li et al (2017) and a six-item measure of perceived enthusiasm. E.g., "please rate the degree of enthusiasm that the entrepreneur displayed throughout the pitch."	Video pitches.

Application to Our Research Data

After creating our AI measures (outlined in-text) we applied them to our data and measured their robustness. We will outline these two steps below.

Calibration—Application of classifiers and weighting. We ran each sentence of our entrepreneurs' dialogue (captured via our main data collection effort, which was independent from the training data set) through the identity centrality and tone analyzer classifiers. Then, we weighted these scores according to the interview length, because longer texts have a greater probability of containing passion than shorter texts. This resulted in a score of identity centrality and affective passion for each observation, with a minimum possible score of 0 and a maximum possible score of 100.

In regards to affective passion, reliability testing indicated that while the Tone Analyzer tool was accurate at detecting the presence of positive emotions (few false negatives, IRR = 92%), it often failed to detect the absence of positive emotion (false positives = 50%). To account for false positives in the tone analyzer, in our use case we undertook a blind assessment of the positive results and removed 154 false positives. IBM Tone Analyzer tool, nonetheless, outperformed other state-of-the-art emotion models with our data (as has been noted elsewhere: Agrawal & An, 2012; Wang & Pal, 2015).

Validating Measures: Robustness Check. While it is generally appropriate with computerized content analysis techniques to manually code a subsample of the data (Lacy & Riffe, 1996), for greater accuracy we chose to code the entire sample to obtain a greater level of confidence in our measures. We deemed this necessary, as the techniques we employed are largely untested in the field of management. One research assistant coded the entirety of the qualitative interviews, blind to our results. We then compared the average scores, from this blind

coding, with the final results to assess the reliability of the classification. The resulting intraclass correlation coefficient was 0.77 (0.80 indicates high “relative consistency in ratings” as per LeBreton & Senter, 2008). Therefore, the pattern of scoring passion is consistent, which provides some confidence in the reliability of the results.

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