Analysis and modeling of the role of laughter in Motivational Interviewing based psychotherapy conversations

Rahul Gupta\textsuperscript{1}, Theodora Chaspari\textsuperscript{1}, Panayiotis Georgiou\textsuperscript{1}, David Atkins\textsuperscript{2}, Shrikanth Narayanan\textsuperscript{1}

\textsuperscript{1}Signal Analysis and Interpretation Lab, University of Southern California, Los Angeles, USA
\textsuperscript{2}Department of Psychiatry and Behavioral Sciences, University of Washington, Seattle, USA

Abstract

Motivational interviewing (MI) is a goal oriented psychotherapy involving natural conversation between a counselor and a client to instill motivation towards behavioral change in the client. Often during such an interaction, the counselor and client express themselves through nonverbal cues such as laughter. We analyze the role of laughers during MI sessions. Specifically, we perform a set of three studies to: (i) Investigate the distribution of utterances containing laughers in an MI session using Poisson process models, (ii) Analyze patterns in counselor and client behaviors with respect to laughter occurrences and (iii) Study the association of counselor utterances high in desirable behaviors such as empathy, acceptance and collaboration (referred to as \textit{BrowniePoint} counselor utterances) with laughers. We quantify the impact of one person's laughter on the laughter rate of the other person. Our results show that the type of laughter (client/counselor stand alone laughter, shared laughter) can be associated with different patterns of counselor/client behaviors and depict unique relations with \textit{BrowniePoint} utterances.

Index Terms: Laughter, Motivational interviewing (MI), Motivational Interviewing Skills Code (MISC), Poisson process

1. Introduction

Motivational interviewing (MI) is extensively used in treating addiction related problems and is defined as “a directive, client-centered counseling style for eliciting behavior change by helping clients to explore and resolve ambivalence” \cite{1}. MI involves a dyadic conversation where a counselor helps the client to perceive both the benefit and harm (e.g. high/health loss) and aims to motivate a positive change. Such conversational interactions often incorporate nonverbal cues, including laughter, the topic of study here. Laughters are associated with several behavioral constructs such as emotional state \cite{2}, temperament \cite{3}, rapport \cite{4} and empathy \cite{5}. Several studies also identify different laughter categories (e.g. voiced vs unvoiced, initiating vs responding) and suggest differences in their functions \cite{6,7}. Understanding the role of laughers may provide a more complete picture of the efficacy of the psychotherapeutic interaction and can inform a more effective execution of the MI protocol. In this work, we perform several experiments to analyze the role of laughers during an MI session. We study the relation between counselor and client laughers and their association with an individual’s behavior. Through these experiments we aim to both offer a means for objectively evaluating the efficacy of an MI session, and offer guidelines for its implementation by answering questions such as “When is it appropriate to laugh?” and “When do laughers relate to an empathetic response?”

Several previous studies have analyzed the role of laughers in human interaction. Glenn \cite{8} explored the role of laughers during an interaction and analyzed the significance of events such as laughing together, the order of laughter and compared laughing at vs. laughing with in social interactions. Similar investigations on laughers in human interactions were made by Jefferson \cite{9} and Herron \cite{10}. Truong et al. \cite{11,12} found similarities in signal characteristics of overlapping laughers against stand alone laughers. They further investigated the relation between initiating and responding laughers and reported prosodic similarities \cite{6}. Other studies have analyzed the relation between laughter and emotion \cite{2,13}, engagement in interaction \cite{14} and health conditions \cite{15,16}. In our previous work \cite{17}, we showed that laughers can help predict client behavior in MI sessions. Our experiments also showed that laughers carry prosodic differences with respect to the client behavior. In this paper, we extend the investigation of laughers in the context of motivational interviewing through computational analysis and modeling. Through these methods, we study the mutual relationship between counselor and client laughers as well as their association with target participant behaviors such as empathic expression. We perform three sets of experiments to: (i) analyze and model the distribution of utterances containing laughers in MI sessions, (ii) identify behavioral patterns based on utterances containing laughers of different types and (iii) study the effect of laughter rates on collaborative (so called \textit{BrowniePoint}) counselor utterances.

(i) Investigating the distribution of utterances containing laughers: We first model the occurrence of utterances containing laughers as a Poisson process (PP). We extend the model by taking into account the laughter events of the other interlocutor. The second model provides us a better predictive fit and suggests an increase in a person’s laughter rate when the other interlocutor laughs.

(ii) Identifying behavioral patterns based on laughter types: To understand the dynamics of an MI therapy session, and to evaluate the efficacy, clinical researchers have developed the Motivational Interviewing Skills Code (MISC) manual \cite{18}. This manual provides an annotation protocol to label each counselor utterance with a behavioral code (e.g. support, reflection) and the client utterances as “change talk” towards/away from a target behavior change like smoking and drugs use. For this paper, we also categorize utterances as carrying no laughter, stand alone client (counselor) laughter or a client (counselor) lead shared laughter. We conduct experiments to quantitatively identify behavioral code patterns specified by MISC in relation to the laughter categories.

(iii) Effect of laughter rates on \textit{BrowniePoint} detection: Counselor utterances high in desirable therapeutic behavior such as empathy, acceptance, collaboration and/or evocation are marked as \textit{BrowniePoint} utterances by MISC annotation. We investigate the relation between laughers rates and such counselor utterances. Our experiments suggest patterns such as shared laughers as being associated with a higher probability of \textit{BrowniePoint} occurrences whereas stand alone counselor laughers lead to a lower likelihood for the same.

We finally discuss the implications of the three experiments for improving the efficacy of motivational interviewing. In the
Couns. - How is it going for you?
Client - I am doing good and my parents are helping me
Couns. - I have been off since a month
Client - But sometimes I feel like going back (Laughs)

Table 1: An excerpt from an MI session with corresponding counselor behavioral codes and client change talk utterance codes. Counselor codes with a smiley ":" represent a BrowniePoint.

<table>
<thead>
<tr>
<th>Counselor behavior codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advice (AD, 511)</td>
</tr>
<tr>
<td>Affirm (AF, 1.9k)</td>
</tr>
<tr>
<td>Confront (CF, 4)</td>
</tr>
<tr>
<td>Direct (DL, 6)</td>
</tr>
<tr>
<td>Emphasize control (EC, 146)</td>
</tr>
<tr>
<td>Facilitate (FA, 17.7k)</td>
</tr>
<tr>
<td>Giving information (GI, 17.8k)</td>
</tr>
<tr>
<td>Question (QU, 9.2k)</td>
</tr>
</tbody>
</table>

| No. of counselor utterances with BrowniePoints: 9.0k |

<table>
<thead>
<tr>
<th>Client change talk utterance codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive valence (CL+, 5.1k)</td>
</tr>
<tr>
<td>No change talk in utterance (CL0, 49.3k)</td>
</tr>
<tr>
<td>Negative valence (CL-, 4.4k)</td>
</tr>
</tbody>
</table>

Table 2: Statistics of counselor behavior codes and client change talk utterance codes over the 242 MI sessions. We show the short representation and count in brackets.

next section, we describe the database, and provide a detailed description of the three experiments in section 3.

2. Database

We use a set of 242 sessions from five MI clinical trials including HMCBI, ESPSB, ESP21, ARC and iCHAMP sessions [19–23]. An excerpt from one such trial is shown in Table 1. Each of these trials was structured to adhere to the MI protocol with the counselor addressing problems such as drug abuse and alcohol addiction with the client. Given the transcripts, between 1-3 annotators mark the utterance boundaries, counselor and client behavioral codes as per the MISC manual. Note that the laughter locations are available in the transcripts. As a majority of files are annotated by one annotator, we use annotations from a single annotator per file for our study. The annotator for files with multiple annotators is chosen randomly. Counselor utterances high in empathy, acceptance, collaboration and/or evocation are marked with a BrowniePoint (represented by a ":").

The MISC manual suggests coding schemes termed as "content codes" and "change talk" codes for counselor and client behavior. A list of counselor behavior codes and client change talk is shown in Table 2 and a detailed description of the codes can be found in the MISC manual [18]. Client utterances reflecting a move towards/away from the desired direction from a target behavior change are termed as positive (negative) "change talk" (e.g. decrease in drug use is a positive change talk). Such utterances are marked as CL+ (CL-) in Table 1. Any other utterance without change talk is shown as CL0. Note that there are a few other MISC protocols, but we do not use them in this work due to incomplete annotation or a large majority of utterances (> 90%) being assigned to a single code under that protocol.

3. Experiments

We perform three sets of experiments to investigate the characteristics of laughter distribution within MI sessions as well as their association with the counselor and client behavior. In the first experiment, we model the arrival of utterances containing laughter as a Poisson process. In the second experiment, we study the relation of counselor and client behavior to laughter. Finally, we investigate the relation of laughter with BrowniePoint assignment. The experiments are described in detail below.

3.1. Distribution of utterances containing laughter

We model the arrival of utterances consisting of client and counselor laughter using Poisson processes (PP). PPs have been widely used to model arrival times of event occurrences such as skin conductance responses [24], heartbeat intervals [25] and software failures [26]. Considering each utterance turn as one time unit, we hypothesize that the arrival times for counselor and client utterances with laughter follow an exponential distribution. PP is characterized by a rate parameter \( \lambda \) such that the expected number of utterances containing laughter per \( T \) utterances is given by \( \lambda \times T \). We estimate \( \lambda \) using a Least Mean Square (LMS) [27] algorithm. We obtain the rate parameters separately for client and counselor utterances containing laughter. During LMS estimation, we use sections of MI sessions with 100 utterances each as instances of PP. In our first model, we assume that \( \lambda \) is a constant value which does not change over time and does not depend on other factors. Such a PP is termed as homogeneous PP (h-PP).

As laughing is sometimes a shared phenomenon [8], we hypothesize that we can improve an interlocutor’s PP model given their association with the counselor and client behavior. In the first experiment, we model the arrival of utterances containing laughter as a Poisson process. In the second experiment, we study the relation of laughter with BrowniePoint assignment. The experiments are described in detail below.

\[
\lambda(t) = \lambda_0 + \lambda_1 \sum_{\tau \text{Set of laughter locations from the other speaker}} R_W(t - \tau) \quad (1)
\]

\( \lambda(t) \) is the rate parameter for the \( t \)th utterance. Note that in this case the rate parameter may vary across utterances unlike a constant rate for h-PP. \( \tau \) represents the utterance indices containing the other interlocutor’s laughter. \( R_W(t - \tau) \) represents a unit rectangular function starting at utterance with index \( \tau \), lasting for \( W \) utterances. \( \lambda_0 \) is the portion of rate parameter which remains constant and an addition of \( \lambda_1 \) is made to the rate parameter for the next \( W \) utterances when the other interlocutor laughs. We estimate \( \lambda_0 \) and \( \lambda_1 \) using the LMS algorithm. \( W \) is tuned for the best log likelihood.

Table 3 shows the rate parameter values and a plot showing \( \lambda(t) \) for utterances in a synthetic session is shown in Figure 1. The rate parameter for h-PP is constant over the session. However an increase in nh-PP rate (\( \lambda(t) \)) is observed for a person when the other interlocutor laughs. We also perform a residual analysis with Kolmogorov-Smirnov (KS) goodness of fit test [28] to compare the empirical Cumulative Distribution Function (CDF) of laughter arrival times and CDF obtained through h-PP and nh-PP modeling. The KS statistics are also shown in Table 3. Notice the improvement in KS statistic using nh-PP over h-PP.

The rate parameter values suggest a higher rate for client laughers than counselor laughers. As seen in the Figure 1, the rate parameter \( \lambda \) for h-PP is slightly higher than \( \lambda_0 \) for
Table 3: Arrival rate of utterances with laughter (per 100 utterances) for homogenous (h-PP) and non-homogeneous PP (nh-PP). Notice the increase in nh-PP laughter rate for a person when the other person laughs.

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Homogeneous PP</th>
<th>Non-Homogeneous PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rate parameter statistic</td>
<td>KS parameter statistic</td>
</tr>
<tr>
<td></td>
<td>$\lambda$</td>
<td>$W$</td>
</tr>
<tr>
<td>Client</td>
<td>2.31</td>
<td>0.057</td>
</tr>
<tr>
<td>Couns.</td>
<td>1.33</td>
<td>0.094</td>
</tr>
</tbody>
</table>

Table 3: Arrival rate of utterances with laughter (per 100 utterances) as estimated using h-PP and nh-PP. All KS statistics of fit are significant at 0.1% level. Also notice improvement in KS statistic when modeling using nh-PP over h-PP.

nh-pp. However $\lambda_1$ accounts for a slight transient increase in both counselor and client laughter rates when the other person laughs. This increase in rate lasts for about thirty utterances for both the participants. The KS statistics provide an evidence that utterances with laughter can be modeled using a PP. Coupling in laughter behavior has been hypothesized by several previous works [8], and in this section we quantify the effect of one person’s laughter on the other by using PP model. Next, we identify patterns in counselor and client behavior with laughter occurrences.

3.2. Identifying behavioral patterns based on laughter type

In an MI setting, client and counselor laughters may occur under specific behavioral backdrops. Moreover, occurrence of shared laughters may provide information regarding the behavioral state of the interlocutors. In this experiment we identify patterns in utterances containing laughters of different types with respect to the counselor and client MISC codes. Initially, we categorize utterances consisting of laughters as being stand alone or shared. Utterances with shared laughters are the ones which are followed by other person’s laughter at least within the next utterance. On the other hand, utterances with stand alone laughters are not surrounded by any other utterance containing laughter. We assign each utterance in an MI session to one of the five utterance categories as listed below along with their counts in the database:

(a) Utterance with no laughter (NL): ~ 117k
(b) Utterance with a stand alone client laughter (SA-Cl): ~2.5k
(c) Utterance with a stand alone counselor laughter (SA-Co): ~1.5k
(d) Utterance with a client-lead shared laughter (Sh-Cl): 227
(e) Utterance with counselor-lead shared laughter (Sh-Co): 149

From the empirical counts, we observe that a higher Sh-Co to SA-Co count ratio (149:1470) than that for Sh-Cl to SA-Cl classes (227:2530). This implies a shared laughter is more likely to be triggered after the counselor laughs. In order to further understand the relation between behavioral codes and laughter occurrences, we train a model to identify the utterance category based on the MISC annotation history. We aim to capture the patterns in interlocutor behavior and the utterance categories using this model. We train a maximum entropy classifier to predict the utterance category using unigrams and bigrams computed on MISC code history as features. For instance, we predict the utterance category of last client utterance in Table 1 based on n-grams computed on the MISC history of CL-, RE, CL+, CL0, QU (please refer to Table 2 for the expansion of each acronym). We perform a leave one session out cross validation for evaluation. For an equal class weighting during training, we downsample the instances from majority classes to contain same number instances as the least represented class.

We report the class recalls in Table 4 along with unweighted average recall (UAR). During training, the window of n-gram history taken into account is tuned by performing an inner cross validation on the training set. A significantly higher UAR over chance value of 20% (binomial proportions test, p-value < 5%) suggests that there exist patterns in behavioral codes with respect to the kind of laughter. However, we observe that class recalls for NL and SA-Co are below chance levels. While this may be an artifact of heavily downsampling the class instances, we nevertheless fail to capture the relation between NL and SA-Co utterances and the MISC annotations. Highest class recalls are observed for classes with shared laughter. This suggests that shared laughters may occur under more structured behavioral circumstances when compared to NL/SA-Co utterances.

We further analyze these relations between n-grams of MISC annotations and the five classes. Figure 2 shows the probability of utterance class given an n-gram as output by a maximum entropy model trained on the entire data. Values are shown only for SA-Cl/ SH-Cl/ SH-Co classes as our model failed to capture patterns in behavioral codes for NL/SA-Co. We list the n-grams associated with highest outcome probabilities for SA-
In our third experiment, we investigate the relation of laughter. They indicate enhanced understanding between the participants. In the x-axis of Figure 2, a value (CL-,RE) implies a bigram of CL- being followed by RE. GI is a unigram representation. Top two n-grams associated with highest probability outcome for SA-Cl (plotted with a red bar) show that such an utterance is likely to happen around the client change talk utterance with a negative change. Thus SA-Cl laughter type associates with an undesired event with client moving away from targeted behavior change. Shared laughters are most likely to happen in a context of the counselor giving information (GI). Bigrams involving combination of GI and Cl0 occur as top two for both of the classes involving shared laughter.

### 3.3. Detecting BrowniePoints based on laughters

Utterances marked with BrowniePoints reflect high degree of empathy, acceptance and/or collaboration by the counselor towards the client. Such utterances are desired in an MI session as they indicate enhanced understanding between the participants. In our third experiment, we investigate the relation of laughters with utterances marked with a BrowniePoint. We initially develop a baseline model to detect utterances with BrowniePoints and evaluate the effect of accounting for laughter behaviors during detection. Specifically, we evaluate the effect of accounting for a global laughter rate as well as local laughter count in detecting BrowniePoints. We describe these models below.

#### 3.3.1. Baseline model for BrowniePoint detection

The entire dataset consists of approximately 9k counselor utterances marked with a BrowniePoint. We train a model to predict if a counselor utterance is a BrowniePoint based on its lexical content. For instance, in Table 1, the model predicts if the second counselor utterance is a BrowniePoint utterance based on the contents of the phrase “Thats a plus”. For BrowniePoint prediction, we train a maximum entropy classifier trained on n-grams extracted from counselor utterances. The model is trained to classify BrowniePoint vs other utterances and is trained on a downsampled set with equal number of BrowniePoint and regular utterances for class balance. Given the BrowniePoint utterances have a relatively rare occurrence, we use Area Under Curve (AUC) of the receiver operating characteristics curve as our metric. We evaluate the baseline model by performing a leave one session out cross validation.

#### 3.3.2. BrowniePoint detection with laughter features

We use two sets of laughter features to evaluate the effect of laughters on BrowniePoint detection. These features reflect an overall laughter rate during the MI session (global laughter rate) and an immediate history of laughter occurrences (local laughter count). We describe them below.

**Global laughter rate**: This feature accounts for the global rate of utterances containing laughters during an MI session. In a session, we again assign utterances with laughters as containing a stand alone client laughter (SACl), stand alone counselor laughter (SACo), client lead shared laughter (ShCl) or counselor lead shared laughter (ShCo) (same assignment criteria as in Section 3.2). We then define a global laughter rate for each utterance category as the average number of utterances between two utterances from that category. A synthetic example for extraction of this feature is shown in Figure 3. Note that this feature will be the same for all utterances from a given session, but will vary across sessions.

**Local laughter count**: This feature yields the utterance type count over the immediate history of an utterance. We again use the four categories of utterances as in global feature computation. Given a window of past utterances categories for an utterance at hand, we count the occurrences of the SACl, SACo, ShCl and ShCo utterances. Please refer to Figure 3 for a sample extraction.

We recompute the AUC values after appending baseline n-gram features with (a) global laughter rate only (b) local laughter count only and (c) both global rate and local laughter count. We use same downsampling and training strategy as in the baseline model. The window length for local laughter count is tuned by inner cross validation on the training set. We list the baseline results and results with laughter features in Table 5.

Results show that both the global and local features improve the BrowniePoint detection. This suggests that occurrences of counselor utterances showing a high empathetic response, acceptance and collaboration is related not only to the immediate laughter context but overall laughing frequency during the MI session. The results reflect a stronger association of BrowniePoints with laughters in the immediate context than the global rate. This finding suggests that empathetic response of counselors correlate with the laughter behavior, apart from the lexical content of utterances.

### 4. Conclusion

Laughters are reflective of emotions, rapport and internal mental state of a person. We performed several experiments to analyze laughter in MI-based psychotherapy settings. We model the joint occurrence of laughters of the counselor and client as Poisson process and observe that a person’s rate of laughter increases when the other interlocutor laughs. We also observe that certain counselor and client behaviors are associated with stand alone client laughters and the shared laughters. Finally, our predictive experiments suggest that the global and local laughter features are positively related to BrowniePoint occurrences. We interpret these findings and derive patterns which can be useful for improving the efficacy of MI protocol including in training counselors.

Similar studies on laughter and other non-verbal cues can be conducted on other domains involving multi-party interactions. Our study needs to be extended to analysis of other aspects related to laughter such as prosody, lexical context and emotion. Laughter is one of the possible non-verbal vocalizations that may include sighs, cries, grunts and such. Investigations that include such broader inventory into the analysis can reveal further insights into the overall role of non-verbal vocal cues in psychotherapy interactions.
5. References


