How Familiarity Influences the Frequency, Temporal Dynamics and Acoustics of Laughter

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***Abstract*—Laughter is an affective and social signal that serves many functions. Similar to other social affective signals, laughter production and perception is at least partially context dependent. Familiarity of conversation partners has been shown to be a contextual influence on laughter production. However, the literature is still scarce and divided on how this complex interaction between familiarity and laughter works. Our goal with this paper is to further study this interaction using a newly acquired and annotated corpus and contrast our findings with existing findings in a comprehensive overview of the literature. Using a series of Linear Mixed-Effect Models, we studied if familiarity with the conversational partner and the sex of same-sex conversation pairs affect the laughter frequency, co-laughter frequency or laughter acoustics produced by the subjects in the corpus. The model outputs show that the frequency of laughter and co-laughter is not influenced by familiarity or the sex of conversation pairs. Interestingly, the percentage of co-laughs is significantly influenced by familiarity. Laughter voicedness is influenced by both the familiarity and sex of conversation pairs, where duration of laughter is only influenced by familiarity of the conversation pair. We conclude that familiarity of conversation pairs play an important role in laughter production during interactions and should be systematically explored. Furthermore we make several suggestions for improving the methods in future work.**

***Index Terms*—laughter, co-laughter, context, familiarity, laugh acoustics, laugh frequency**

I. Introduction

Laughter as an affective and social signal pervades human societies all over the world and is one of the most common non-verbal social signals. Across cultures, laughter is used in social settings for a variety of reasons ranging from expressing joy or mirth, to trying to influence the discourse by the person that laughs. Laughter is also hypothesised to induce positive feelings in others and is important in bonding between individuals among other things [1]. Laughter thus plays a key role in regulating social interactions.

How laughter is produced and perceived during communication, is like many other social signals at least partly context dependent. Research on the importance of context for both human and machine understanding of similar human affective and social signals has gained traction more recently [2]–[4]. Within laughter research several context features have been explored in terms of their influence on laugh perception and production. Regarding laughter perception, the influence of both acoustic features of laughter [5]–[8] and their social context has been studied [9]–[13]. Laughter production has been studied in different contextual settings with some work focusing on group size as an important context, including dyadic conversations [14]–[18] and multi-party groups [19]–[22]. Other studies control for, or focus on demographic contextual influences including sex [23], [24], gender [25], age, culture, language or a combination of these [21], [25], [26]. Another body of research mainly focuses on conversational function in relation to laughter production [6], [27]–[29].

A different and important context which is the focus of this paper, is the level of familiarity between conversation partners: the degree to how well conversation partners know each other and the type of relationship they have. Familiarity as a contextual influence on communication has been widely recognised. For example, two social mechanisms that familiar individuals among each other display are an increased tendency for mimicry and synchrony of each others expression of social signals [30], [31]. The level of familiarity between individuals not only influences the frequency and temporal patterns in communication, it also influences the way people speak amongst each other, more specifically the acoustic features of their speech [32], [33]. Given the effects of familiarity on social interaction and speech, we expect familiarity to play an equally important role in a social signal like laughter.

A few studies have investigated the relationship between laughter and familiarity. They primarily looked at two topics, first the relation with the frequency of different types of laughter [34]–[36] and how much these laughs overlap between laughers [34], [37], [38] and secondly the acoustic features of laughs in these settings [26], [37]. The research carried out so far indicates that contextual influences of familiarity between individuals on laughter frequencies and acoustics exist, but are most likely complex in their working showing sometimes seemingly conflicting results. Adding to the complexity is the fact that some of the previously mentioned literature found influences of the sex of conversation partners on laughter production in familiar and unfamiliar settings [34], [37], [38]. Some of the current challenges are that the existing literature is scarce, use (sometimes unavailable) data captured in different settings and operationalize familiarity differently, making it difficult to gauge and compare findings to further grow our understanding of the complex relationship between familiarity and laughter.

Our goal with this paper is to further advance the understanding of the relationship between familiarity and laughter. Furthermore we discuss current methods used in the field and make some suggestions for a more comparable and fine-drawn way for future work to further explore this topic. To aid our intentions we present a novel, annotated, database containing laughter that follows subjects in two different conversational settings; a setting where the subjects talk with someone they know well (familiar condition) and a setting with someone they do not know (unfamiliar condition). With this database we will explore within-person differences in frequencies, temporal dynamics and acoustics of laughter produced in familiar and unfamiliar settings. We therefore pose the following research question; *Do familiarity with the conversational partner and the sex of same-sex conversation pairs affect the laughter frequency, co-laughter frequency or laughter acoustics produced by the subjects?* We contrast our findings with existing literature, contribute our insights into how laughter is shaped by familiarity as a context factor and how future research could further grow this understanding.

II. Related work

To better understand the implications of current research findings, we will first discuss how familiarity could be defined and measured between conversation pairs. This remains one of the main challenges for this field and there is no golden standard yet. Afterwards we will give a quick overview of the previous work that relate to familiarity and laughter, in table I we provide a detailed overview of the discussed studies in order to aid comparison of study outcomes and designs.

A. Measuring familiarity

Familiarity between individuals has been operationalized in many different ways throughout scientific literature, but lacks a universally accepted definition. Within laughter research this is no different and several ways of measuring or inferring the level of familiarity and its influence on laughter have been used.

There are studies that focus on familiarity as a binary concept, studying subjects that either know each other or do not [26], [33]–[37], [39], whereas only a few others identify familiarity more in terms of relationship categories or use multidimensional concepts and related scales. For example [38] uses several validated scales to measure different aspects of relationships including perceived relational closeness, social support, satisfaction, passion and commitment. Often authors implicitly assume differences in familiarity based on the design of their study and do not specify how they verified these levels of familiarity [34], [35]. Other authors described the levels of familiarity in a more minimal way (e.g. the participants were roommates who knew each other at most 2 weeks), but did not systematically measure or record this [26], [33], [36], [37], [39]. This lays bare some challenges for the laughter and familiarity research field, namely the absence of systematically describing and measuring levels of familiarity and related to this, the lack of approaches that makes use of finer grained constructs related to familiarity such as the quality of relationships.

Most studies choose to compare familiarity using a between-subjects design, matching familiar or unfamiliar conversation partners and comparing laughter between these two groups of conversation pairs. An interesting exception here are the works of [26], [33], [37], who compare familiarity conditions using a within-subjects design. In these studies conversation partners were followed over time in order to see how the development of a relationship over multiple meetings influenced the laughter produced during these conversations. Although within-subject designed studies have their own challenges, one major advantage is that researchers can control for individual differences, something which is important when researching a heterogeneous social signal such as laughter.

B. Familiarity as a context in laughter research

The relationship between familiarity among conversation partners and the amount and type of laughter they produce has been studied with a focus on laughter frequencies and laughter acoustics. Literature regarding these two topics is unfortunately scarce and sometimes produce conflicting results. For example, when [34] looked at the frequency of laughter occurrences, the authors did find a positive relationship between how much the subjects of their study laughed and the level of familiarity among conversation pairs. According to their results, the more familiar conversation partners are with each other, the more they laugh. This result was independent of the sex composition of each pair. However, other studies did not find such a correlation between familiarity level and the amount of laughter [35], [36].

Familiarity in relation to the frequency of co-laughter, when conversation partners laugh at the same moment, has also been studied. Smoski and Bachorowski [34] found significantly more co-laughter occurring between friends than between strangers. In another study [37], they looked at how co-laughter quantified over the development of friendships, where they recorded short conversations between conversation pairs over the span of three months. Results of this study showed that there was a clear influence of the sex of the conversation pairs with female same-sex conversation pairs developing co-laughter much earlier on average within 3 weeks and male same-sex conversation pairs developing co-laughter on average within 6 weeks. A more recent investigation [38] identified that proportions of co-laughter compared to the total of laughter was positively related to relationship quality, closeness and social support among romantic couples.

Regarding the acoustics of laughter in familiar and unfamiliar conversation pairs, [26], [33] showed that laugh style (speech-laughs or laugh bouts) and laugh acoustics, among which voicedness, were influenced by the level of familiarity in developing friendships. Supporting the notion that familiarity context could influence laughter acoustics perceivable by conversation partners, [39] studied if individuals were able to

TABLE I

THIS TABLE CONTAINS AN OVERVIEW OF THE CURRENT RESEARCH THAT FOCUSES ON FAMILIARITY AS A CONTEXT FOR LAUGHTER. THE COLUMNS REPRESENT FROM LEFT TO RIGHT: FIRST AUTHOR AND REFERENCE, THE NUMBER OF LAUGHS AND CO-LAUGHS USED IN ANALYSIS, THE NUMBER OF SUBJECTS IN THE STUDY, THE AVERAGE DURATION AND CATEGORIES OF INTERACTIONS PRESENT IN THE STUDY, THE DESIGN OF THE STUDY AS DESCRIBED IN THE TEXT, RESEARCH TOPICS RELATED TO ACOUSTICS OF LAUGHTER AND ALL MAIN CONCLUSIONS RELATED TO THE RESEARCH TOPICS. - = NECESSARY INFORMATION NOT IN TEXT, *L* = OVERALL NUMBER OF LAUGHS, *CL* = OVERALL NUMBER OF CO-LAUGHS, *OI* = OPEN AND UNCONTROLLED INTERACTIONS, *TBI* = TASK-BASED OR GAME-BASED INTERACTIONS, *V* = VOICEDNESS OF LAUGHTER, *D* = DURATION OF LAUGHTER, *X* = OTHER ACOUSTIC FEATURES WERE ALSO INVESTIGATED, *NA* = NO ACOUSTIC FEATURES RESEARCHED.

Author	Laughter	Subjects	Interaction	Design	Acoustics	Conclusion
Current study	*2566L, 576CL*	*69*	*OC<30min*	*Within, Between*	*V, D*	*No correlation fam./sex of pair and laughter/co-laughter freq. No correlation fam. and co-laughter percentages of laughs. Correlation fam./sex of pair and laughter voicedness. Correlation fam. of conversation pair and laughter duration.*
Smoski 2003a [34]	1770L,-	148	TBI<30min	Between	NA	Correlation fam./sex of partner and overall/co-laughs. Fam. pairs show more co-laughter than unfam. pairs. Within mixed-sex pairs, females produce more co-laughs.
Smoski 2003b [37]	-,-	72	TBI<30min	Within, Between	NA	Fam. developed more in friends than strangers. Female friends produce more co-laughs after 3 weeks. Male friends produce more co-laughs after 6 weeks. Acoustic properties might elicit co-laughs.
Vettin 2004 [35]	1921L,-	10	OC>30min	Between	NA	No correlation fam. and overall laughter freq.
Campbell 2007a [26]	3130L,-	10	OC=30min	Within	V, D, X	Correlation fam. and laugh acoustics.
Campbell 2007b [33]	3130L,-	10	OC=30min	Within	V, D, X	Correlation fam. and laughter voicedness/duration.
Trouvain 2012 [36]	-/-	40+64	TBI<30min	Between	NA	No correlation fam. and laughter occurences.
Kurtz 2015 [38]	1133L, 256CL	142	OC>30min	Between	NA	Correlation fam. (*multi-dimensional*) and co-laughs ratios.

identify whether decontextualised co-laughter was produced in a familiar or unfamiliar conversation pair and found that individuals were able to do this remarkably well.

Co-laughter on itself seems to be also correlated with some laughter acoustics, for example [40], [41] found for all the corpora studied that overlapping laughs are longer in duration and are generally more voiced than non-overlapping laughs. Smoski and Bachorowski [37] looked at the acoustic features produced by familiar and unfamiliar conversation partners: here a positive relationship between voiced, affect inducing laughs and the production of co-laughter was found. The results from these studies might partially explain the findings from other researchers that familiar couples show more voiced laughter [26], [33] and therefore we will incorporate co-laughter into our models when exploring laughter acoustics.

III. METHODS

A. Data

Available corpora that measure any kind of familiarity and contain annotated laughter are scarce. To the authors knowledge only two corpora are currently available and contain laughter annotated interactions between familiar or unfamiliar conversation partners, The NOMCO corpus [42] and the HCRC map task corpus [43]. Unfortunately these two databases did not fit our criteria, since we were looking for a corpus containing spontaneous English spoken interactions between familiar and unfamiliar pairs that were annotated according to or at least with a similar laughter annotation scheme as proposed in [44].

In order to explore and answer the research questions posed in the introduction and to avoid limitations imposed by similar currently available corpora, we collected and annotated a new corpus in March 2020. This corpus was also recorded for educational purposes. Given the recent worldwide events at the time, participant well-being had an even higher priority and therefore we designed a database focusing exclusively on non-physical, online interactions between same-sex conversation pairs familiar to each other or unfamiliar to each other. One of the main benefits of this online set-up is that audio channels are completely split and no confounding happens between the channel recordings, aiding in the laughter annotation process as well as the analysis of acoustic features of laughter. Table II provides some descriptive statistics from our new database.

The corpus contains several different social conversational tasks between participant pairs in a private online meeting setting. The main task of this corpus was a 10-20 minute long open conversation, which was both screen captured through the conference software as well as audio recorded using separate microphones available to the participants. The conversation pairs were invited to start an open conversation about any topic they preferred, as long as the conversation topic was not offensive or disclosed any private information. We chose this flexible time window to make the conversations feel as natural as possible, simulating short daily and random encounters between either familiar individuals or unfamiliar individuals. Figure 1 shows two screenshots of different same-sex conversation pairs, giving an impression of the recorded main task in the corpus.

Other recorded tasks and scenarios were more specifically focused on putting participants in roles or situations that potentially elicit various kinds of laughter. These include a task where participants had to discuss a list of survival tools they would like to have when stranded on an island, joke telling rounds and a role playing scenario where participants were put in either a more dominant role or a more co-operative role.

Participants filled in some questions before, during and

TABLE II

THIS TABLE CONTAINS SOME DESCRIPTIVE STATISTICS OF THE NEW DATABASE INCLUDING THE DURATION OF INTERACTIONS IN MINUTES (*std.*), TOTAL NUMBER OF LAUGHS, AVERAGE LAUGHS PER MINUTE OVER THE PARTICIPANTS (*std.*), AVERAGE LAUGHS PER MINUTE OVER THE CONVERSATION PAIRS (*std.*), NUMBER OF CO-LAUGHS, AVERAGE CO-LAUGHS PER MINUTE OVER THE PARTICIPANTS (*std.*), AVERAGE LAUGHTER VOICEDNESS PERCENTAGE (*std.*) AND AVERAGE LAUGHTER DURATION IN SECONDS (*std.*). THE COLUMNS REPRESENT THE FULL DATABASE, AND SUBGROUPS BASED ON THE CONDITIONS FAMILIARITY AND SEX.

	Overall	**Fam. female**	**Fam. male**	**Unfam. female**	**Unfam. male**
Average duration of interactions (min.)	14.72 (*3.44*)	15.06 (*3.63*)	15.45 (*4.24*)	14.16 (*2.63*)	13.87 (*2.41*)
Number of laughs	2566	738	675	802	351
Average laughs p/m participant	3.47 (*2.03*)	3.70 (*2.60*)	3.81 (*2.10*)	3.34 (*1.37*)	2.65 (*1.44*)
Average laughs p/m conversation pair	5.64 (*2.59*)	5.36 (*2.49*)	6.48 (*3.48*)	4.04 (*1.78*)	5.90 (*1.14*)
Number of co-laughs	576	182	167	176	51
Average co-laughs p/m participant	0.92 (*0.52*)	1.01 (*0.62*)	1.02 (*0.48*)	0.88 (*0.38*)	0.35 (*0.10*)
Average laughter voicedness (perc.)	0.54 (*0.29*)	0.61 (*0.28*)	0.41 (*0.26*)	0.62 (*0.26*)	0.42 (*0.27*)
Average laughter duration (sec.)	0.83 (*0.73*)	0.85 (*0.71*)	0.96 (*0.91*)	0.71 (*0.54*)	0.81 (*0.73*)

Fig. 1. Two examples screenshots of captured interactions between same-sex conversation pairs during the main task. Faces are blurred out.

after the recordings that were focused on gathering data on familiarity with the other participant in the conversation, their own current mood and emotions they were experiencing. These questions were used to check if any individual conditions might have influenced the sessions and to explore the development of the relationship between conversation pairs. Unfortunately due to missing data, we could not incorporate these scores in our analysis.

B. Participants

University students from a course on Affective Computing were asked to record a meeting with a participant they recruited and knew well and in a similar approach as in [43], meet with a second participant recruited by another student. In total 23 students recorded interactions over two meetings, one meeting with a familiar person (e.g. a friend or family member) and one meeting with an unfamiliar person (a stranger). After excluding participants who retracted their consent or did not adhere to the database collection protocol, the corpus contains 46 dyadic conversation pairs interacting, 24 familiar pairs and 22 unfamiliar pairs.

Students recruited a same-sex participant they knew well and recruited another participant who was to be matched with a same-sex student they did not know beforehand. We chose to match same-sex conversation pairs since previous work has shown that male and female same-sex conversation pairs differ in antiphonal laughter, which was apparent in developing relationships [45]. The authors further matched participants on demographic features such as age and cultural background within pairs to be able to control possible confounding effects from these features better. Participants age ranged from 18 to 30 years with a mean age of 25. Cultural background varied somewhat due to the amount of international students participating in the course. In total 30 males and 39 females participated in this data collection.

C. Laugh segmentation and labelling

Laughter segmentation and labelling are a challenge within laughter research due to heterogeneous terminology and often general definitions of laughter. Our definitions and annotations are inspired by two interesting annotation approaches proposed by [44] and [46] respectively. During annotation of our database we chose to segment two physically different forms of laughter, laughter bouts and speech-laughs. A laughter bout is defined as laugh-like syllable or a sequence of laugh-like syllables that are produced in one exhalation phase. A bout can be, and often is separated by an in-breath at the start or end of the laugh bout. Speech-laughs are defined as a stretch of articulated speech with laughter interspersed.

In addition to the segmentation and identification of laugh bouts and speech-laughs, laughter is labelled on three tiers inspired by [46]. In the first tier, raters indicated the perceived arousal (low-medium-high). In the next tier, raters decided whether the laugh was isolated, following another laugh or preceding a laugh of the opposite interaction partner. The final tier queried the cause of the laugh, subdividing the causes in pleasant incongruity, social incongruity, pragmatic incongruity, pleasantness or other causes as is further described by [46].

Students provided initial annotations on the segments they recorded and that were related to the conversational task. In a later stage an experienced laughter annotator did go over these recorded documents and the student annotations. This experienced laughter annotator added missing laughs and corrected existing laugh annotations, specifically laughs were segmented and labelled 'speech-laughs' or 'laugh-bouts'. Due to resource constraints, no annotations were corrected for the other labels that were inspired by [46], these labels are also not used in the analysis.

D. Analysis of Data

Due to the mixed design of the data collection, there are both within person repeated measures (the students) and between person measures (their conversation partners) over the two conditions (familiar pairs and unfamiliar pairs). We choose to focus on the within-person repeated measures of frequency and acoustics of laughter produced by the students from the corpus collection in the familiar and unfamiliar conditions. By using these within-person repeated measures, we aim to be able to better account for the fairly high individual differences (Table II). Another argument for this analysis is that student recordings were found to be slightly higher in quality overall after reviewing the recordings. In order to cope with the somewhat unbalanced data we carried out a series of Linear Mixed-Effect Models, which are more flexible than more traditional models. The lme4 [47] and lmerTest [48] packages in R are used to fit the models. Within these models familiarity and sex of the conversation pair are fixed effects since we expect these to correlate with laughter frequencies and acoustics based on literature. Individual differences within the model will be accounted for by using subjects as a random effect. The model outputs have been summarised in table III. In the next section we will describe the results of the mentioned statistical tests in terms of our hypothesis.

IV. Results

A. Laughter frequency

We investigated the average frequency of laughter per minute over the conversations. We carried out a Linear Mixed-Effect Model analysis with the results being displayed under 'Model-1' in table III. In our sample there was no significant relationship between the familiarity or the sex of the conversation pair and the average number of laughs per minute. The model (slope) estimates are smaller than their respective errors, which further strengthens the non-significant results. 42% of variance unexplained by the fixed factors could be attributed to the random subject effect in this model.

B. Co-laughter frequency

With regards to co-laughter, we investigated the average number of co-laughs produced by a participant over the conversations. For this analysis we assigned laughs to either being co-laughter, when there was any temporal overlap between the pairs laughter, or not co-laughter. We carried out a Linear Mixed-Effects Model analysis with the results being displayed under 'Model-2' in table III. In our sample there was no significant relationship between the familiarity or the sex of the conversation pair and the average number of co-laughs per minute. A fair amount (44%) of variance unexplained by the fixed factors could be attributed to the random effect in this model.

We also investigated the ratio between co-laughter and non co-laughter over the conversations. Here we looked at the percentage of co-laughs within all the laughs of the conversation. We carried out a Mixed Effects Regression Model analysis with the results being displayed under 'Model-3' in table III. The model shows a significant effect of the familiarity condition on the ratio of co-laughs ($p < 0.01$), with students that are paired with a familiar conversation partner producing relatively more co-laughter than students paired with an unfamiliar conversation partner. The sex of the conversation pair does not show a significant effect. About 53% of the variance that is not explained by the fixed factors can be attributed to individual differences.

C. Laughter acoustics

The other two Linear Mixed-Effect Models used acoustics of laughter as fixed effects, more specifically we looked at two acoustic features that were also used in previous studies; the percentage of voiced frames in laughter and the duration of laughter. A difference with the previous models is that the percentage of co-laughs compared to the total amount of laughter by the students was included as an extra random effect for the reasons described earlier in this paper. We used AIC model selection to distinguish if the extended models had a significant improved fit, this was the case for both extended models described in this paragraph. The results of these two models are displayed respectively under 'Model-4' and 'Model-5' in table III.

The voicedness of laughter is significantly influenced by both familiarity ($p < 0.001$) and sex ($p < 0.05$) of the conversation pair, with familiar students and male students producing slightly less voiced frames in their laughs. Respectively, about 29% and 10% of the variance unexplained by the fixed factors could be attributed to individual differences and the amount of co-laughter.

With regards to laughter duration, familiarity significantly influences the duration of laughter ($p < 0.001$). Students laughed longer when in a conversation with a familiar conversation partner. The sex of the conversation pair did not significantly influence the duration of laughter. Within this model individual differences explained approximately 17% and the amount of co-laughter explained 22% of the variance that was not explained by fixed factors.

V. Discussion and conclusion

A. Findings of current study in light of past studies

1) Does familiarity and sex of the conversation pair influence laughter and co-laughter frequency: The results from the statistical tests indicate that familiarity and sex of same-sex conversation pairs do not play a significant role in how frequent students laughed in our data, and therefore supported findings of [35], [36]. In addition there were also no significant effects of familiarity and sex of same-sex conversation pairs on how frequent students produced co-laughter. However, when

TABLE III
MODEL ESTIMATES OF THE FIXED EFFECTS FAMILIARITY WITH CONVERSATION PARTNER AND SEX OF THE CONVERSATION PAIR ON AVERAGE LAUGHTER FREQUENCY PER MINUTE FOR STUDENTS (MODEL 1), AVERAGE CO-LAUGHTER FREQUENCY PER MINUTE FOR STUDENTS (MODEL 2), THE RATIO/PERCENTAGES OF CO-LAUGHTER COMPARED TO THE TOTAL AMOUNTS OF LAUGHTER BY STUDENTS (MODEL 3), THE PERCENTAGE OF VOICED FRAMES IN LAUGHTER OF STUDENTS (MODEL 4) AND THE DURATION OF LAUGHTER (MODEL 5) IN A LINEAR MIXED-EFFECT MODEL WITH SUBJECTS AS A RANDOM EFFECT. *These models contain a second random effect that accounts for the percentages of co-laughter within the overall amount of laughter the students produce.*

	β	**SE**	**CI**	***P***
Model-1				
Familiarity	0.0224	0.1442	-0.2672/0.3120	0.878
Sex of pair	-0.1621	0.2350	-0.6208/0.2966	0.500
Model-2				
Familiarity	-0.4330	0.2668	0.9723/0.1064	0.127
Sex of pair	-0.5606	0.4279	-1.3941/0.2729	0.213
Model-3				
Familiarity	-0.7576	0.2202	-1.2027/-0.3124	**0.0040**
Sex of pair	-0.7324	0.4009	-1.5133/0.0484	0.0907
Model-4*				
Familiarity	0.3193	0.0610	0.2002/0.4401	**$p < 0.001$**
Sex of pair	-0.6003	0.2498	-1.0878/-0.1116	**0.0279**
Model-5*				
Familiarity	-0.2797	0.0631	-0.4032/-0.1542	**$p < 0.001$**
Sex of pair	0.1338	0.2132	-0.2940/0.5584	0.5380

we look at the percentage of co-laughs compared to the total amount of laughter from the student, familiarity does significantly influence the percentage of co-laughs. Students in familiar conversation pairs showed more co-laughter relative to the total laughs. The significant effect of familiarity on co-laughter is mostly in line with the literature [37], [38]. The differences in results between the models for overall frequency of co-laughter and the percentage of co-laughter highlight the importance of correctly choosing and clearly describing the right variable to represent changes in laughter.

2) Does familiarity and sex of the conversation pair influence laughter acoustics: In addition, familiarity did significantly correlate with how participants laughed in terms of the voicedness and duration of laughs which is in line with [26], [32], [37]. We controlled here for the percentage of co-laughter in the conversation since literature reveals that co-laughter on itself also shows higher amounts of voicedness and longer duration compared to non co-laughter [40], [41]. Interestingly controlling for the percentage of co-laughter helped improve the fit of the model. The significance and direction of the effect of familiarity on voicedness and duration of laughter did not change much however. It seems like percentages of co-laughter primarily explain a part of the variance unexplained by the fixed effects. The sex of the conversation pair has a significant effect on the voicedness of laughter produced by the students. This is in line with some findings from [37] but it might also be a more general effect independent from familiarity. The results confirm some of the findings in literature but also again emphasise the complexity and subtlety in which ways familiarity might influence laughter between conversational pairs.

B. Limitations of current study

Although we put much effort in carefully designing the study, it has some short-comings that should be mentioned here. One of the main decisions we took as a result of the global pandemic was to record our corpus in an online setting. Although this setting has several advantages, including a good split of audio recordings, it also has a considerable drawback. There was less control during the recording and we had to rely on participants seriously following a script. This short-coming in combination with a lack of standardized hardware and technical errors bound to happen in such setting, resulted in that we had to exclude quite some recordings. Which in turn caused a sex dis-balance among conversation pairs.

The second complicating factor is the nested structure of our corpus, which was initially meant as a full within person design, but it was decided to change the original study design in favour of the current design in order to minimise the burden of recruiting several participants on students already in a challenging situation. The design and the dis-balance in sex excluded some statistical models that could fit the data and answer our research questions, in addition the sample used for our models shrunk slightly compared to a model that could incorporate all participants.

C. Beyond the current study

With the current study we aimed to compare our findings with existing literature on the effects of familiarity on laughter. Although our results might be guiding for future research, they are in no means definitive answers. We believe that our contributions with this work are the construction of a new useful familiarity and laughter annotated corpus, presenting an overview of the results of previous research and contrasting the results with our findings from this new singular corpus. We also think it is important to discuss insights we gained and make suggestions on how to do future research on the relationship between familiarity and laughter. Most of these suggestions are related to issues that might help explain the difficulties of comparing results and explaining conflicting findings.

One suggestion for future work is related to how familiarity is measured and operationalized. We believe it is important to look beyond familiarity as a binary concept and encourage researchers to consider different levels of familiarity [37] or even consider looking at relationship aspects, which was for example done by [38]. Measuring different levels or aspects of familiarity will give insights into potential individual differences in how familiarity and laughter production influence correlate. These familiarity aspects could be measured using validated scales as used in several other scientific fields, several examples of these validated scales can be found in the study of [38]. Using validated scales has the added benefit of making studies more comparable and replicateable. Related to the previous suggestion, it is important to be consistent in future work in how we define other important and related concepts such as co-laughter.

Furthermore we believe that defining and clearly describing how laughter is segmented and labelled within future work could help researchers better compare their results. The segmentation and labelling of laughter is a far from closed discussion in the laughter research field in general [44], [46], and is an equally important topic for research on familiarity and laughter.

Another way to improve future research could be by carefully considering whether to use a within or between subjects design for your study. It is true that within subject designs can be more difficult to realise, but it is important to consider the benefit of limiting the influence of individual differences by using a within subject design. Our results often show that individual differences do explain a large proportion of the variance in our data, which is to be expected with such a diverse social signal. An interesting consideration here is how to measure familiarity in a within subject design. Researchers could look at the development of familiarity between two participants over multiple sessions, or match up a participant with other participants that have different levels of familiarity.

Finally we suggest adopting the good practice of describing the context of the corpus in a consistent and well documented way. Laughter is a highly variable signal that is context dependent. We believe that capturing this context in the study or corpus description would aid a better understanding of the results and help other researchers replicate findings. For more information and suggestions on this subject we refer to [49].

The findings of our paper illustrate that familiarity plays a significant role in both laughter occurrences and laughter acoustics in a conversational context. These results contribute to bigger questions in affective computing namely how context variables (e.g., familiarity) influence automatic recognition and synthesis of affective expressions, and may inform future design of context-aware conversational agents.

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