Look What I Made It Do - Modeling Nonverbal Agent Behavior Manually From Literature: The ModelIT Method

ABSTRACT

Nonverbal behavior of socially interactive agents (SIAs) is often automatically generated and identical across all users. This approach, though economic, might have counterproductive effects when designing applications for diverse and vulnerable populations. Also, it might negatively impact research validity and diminish the effectiveness of SIA-based interventions. This paper presents arguments for and proposes a method to model nonverbal behavior in SIAs. The ModelIT method enables researchers to ground the modelling of nonverbal behaviors in psychological theories. It aims at establishing a standardized and replicable method that promotes open science practices and facilitates the creation of tailored SIAs. It is a step towards barrier-free and accessible SIA applications across diverse populations. The necessity, guidelines, and limitations of the ModelIT method are thoroughly addressed.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**; **Interaction design process and methods**; **Accessibility design and evaluation methods**.

KEYWORDS

Socially Interactive Agents, Nonverbal Behavior, Method, Replicability

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1 INTRODUCTION

Nonverbal behavior plays a fundamental role in human interaction, enriching and underlining communication [12]. While humans primarily engage with other humans, in recent years these interactions include objects such as computers. In the context of human-computer interaction (HCI), the study of nonverbal behavior has garnered increased attention, particularly when it involves socially interactive agents (SIAs) that possess an embodied and humanoid presence. While for specialized interpersonal tasks, humans primarily engage with other humans, SIAs are becoming more and more capable of entering these spaces and performing these tasks. In a world with a rising shortage of specialists, embodied SIAs are the future of health-care [16, 29], teaching [7], coaching [36, 37], and many more previously human-dominated fields targeting divers user groups with diverse needs. Vulnerable populations (e.g., people in in-patient facilities) make up a huge target audience for SIA applications, such as therapy-accompanying SIAs that helps users identify and evaluate automatic thoughts [39].

Though modelling of nonverbal SIA behavior has been an important research focus for years [32], there exists no standardized approach, how to model the nonverbal SIA behavior for users with diverse needs (e.g., diverse and vulnerable populations). These needs have to be identified, extracted, carefully operationalized, implemented, and validated to create SIAs that can now successfully support their intended population. Therefore, this paper aims to establish and advocate for a standardized method, the ModelIT method, for extracting nonverbal cues from literature and applying them to SIA animation. The goal is to create specialized and optimized SIAs that can confidently serve their intended purpose. It is a step towards barrier-free and equality-focused applications. The proposed ModelIT method seeks to minimize subjective biases, ensure maximum objectivity, and increase replicability, while considering current limitations of available technical tools.

2 BACKGROUND

2.1 Nonverbal Behavior in Human-Human-Interaction

Nonverbal behavior, including posture, movements, and facial expressions [25], serves several important functions in human-human interaction [26]. It is a fundamental part of building rapport [40], eliciting trust [19], and establishing how a person is perceived [11]. Nonverbal behavior has been studied as a whole for a long time, but in recent years research has also focused on the many existing interpersonal differences [6, 8, 13] identifying specific needs of different populations.

2.1.1 Clinical and neurodiverse populations. The display as well as the interpretation of nonverbal cues differ greatly when focusing on clinical or neurodiverse populations. Nonverbal behaviors that are, in general, assessed as rather positive, can be perceived as negative. For example, eye contact is usually associated with social presence [10] and is therefore used to build trust and signify active listening to the interaction partner [14]. However, autistic people can find direct eye contact uncomfortable [34]. Consequently, nonverbal behavior should be actively adapted when interacting with an autistic person with that specific need to make them feel more comfortable.

2.1.2 Culturally diverse populations. Nonverbal behavior patterns and their communicated meaning also vary significantly between different cultures [22]. This should be taken into account during interactions with individuals from different cultural backgrounds, as failure to do so can lead to miscommunication. In some Asian countries like China, shaking one's head is a nonverbal cue for "yes". It is also seen as rude to contradict another person [23],

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whereas in many central European countries, a head-shake means "no" and contradicting is a normal part of an interaction. These two differences by themselves and especially together can easily generate conflict if one of the interaction partners is not aware.

2.2 Nonverbal Behavior in Human-SIA-Interaction

Socially Interactive Agents (SIAs) are virtually or physically embodied agents. They are capable of socially intelligent autonomous communication with human users and other agents. This is executed with a wide range of multi-modal behaviors [20]. As humans tend to interact with machines similarly as with humans, the principles of human-human-interaction can be applied to human-SIA interaction [33]. Users expect their SIA partner to act and react in certain ways and attribute human characteristics accordingly [24].

The expression of nonverbal behavior in SIAs influences how they are perceived by a user [35]. The modelling of nonverbal SIA behavior has been an important research focus for years [32]. It stays relevant to this day as human behavior is complex and the technology becomes more sophisticated. The standard procedures of modelling nonverbal SIA behavior should therefore also be periodically reconsidered.

Automatic generation of nonverbal behavior has been commonly used in the field of SIAs [35]. Many SIA systems utilize pre-programmed algorithms to automatically generate gestures, facial expressions, body movements, and other nonverbal cues. While this approach guarantees a consistent user-experience, it does not really address the many interpersonal differences in human interaction. Those differences become more relevant the more SIA applications exist for a broader spectrum of people.

2.2.1 Clinical and neurodiverse populations. Eye contact is generally associated with social presence [10]. Therefore SIAs are often modelled to seek eye contact with their user to build trust. When autistic people interact with a SIA designed that way, this effect could be completely lost. The effectiveness of the application can be compromised. This makes an explicitly different modeling of eye gaze essential, especially for the various applications of SIAs designed for autistic people [30]. This is only one use-case where standardized nonverbal behavior can be counterproductive and possibly discriminatory. It has the potential to compromise the validity of research and impact real-life applications.

2.2.2 Culturally diverse populations. Culturally varying nonverbal behavior patterns must be considered when developing SIA applications that are used interculturally. Consequently a SIA-application designed with a North American user-base in mind, might completely lose its functionality when implemented for a Syrian refugee program.

2.3 Attachment Style

Attachment styles were first observed in children [1] and characterized as collections of internal working models influencing new relationships and one's self-perception [21, 38]. Adult attachment [17] introduced a mapping of those existing attachment style categories onto adults. There are several different systems of categorization, that have been used. There is often a general distinction between secure and insecure attachment [1]. The latter can be subdivided into different types of insecure attachment. A prominent categorization of insecure attachment is: dismissing, preoccupied, and unresolved [9]. There are also continual dimensions to measure attachment style [5]. Those dimensions are attachment anxiety and attachment avoidance and a person can have high or low scores on either. Based in these scores, four categories can be discerned: secure (low anxiety, low avoidance), preoccupied (high anxiety, low avoidance), dismissing (low anxiety, high avoidance), and fearful (high anxiety, high avoidance). The attachment style of a person influences their nonverbal behavior in attachment related situations [3]. Securely attached people generate intimacy easily [2]. Individuals with high attachment anxiety use anger in attachment related situations [27] while people with high attachment avoidance employ distancing strategies [28].

3 THE MODELIT METHOD

The ModelIT method is a method for a standardized modeling of nonverbal behavior in SIAs. It can be applied to a specific use-case that defines the characteristics of the SIA and the possible needs of the specific user population. It consists of five steps that lead from an abstract to an applied level: (1) literature review; (2) nonverbal behavior extraction; (3) nonverbal cue operationalization; (4) nonverbal cue implementation; and (5) validation.

These five steps are a necessary concretisation process because nonverbal cues are frequently not defined in an applicable way in existing literature. Especially when designing a SIA for a specific population, most nonverbal behavior is extremely complex and only vaguely described over a vast quantity of research papers. For example, people with high attachment anxiety regulate distress by seeking closeness [2]. This cannot be directly implemented into an animation but has to undergo a concretisation process to be actually usable.

In this work, the baseline behavior of the SIA has been manually authored. However, given the possibility to express such rules with a formalism that can be programmatically interpreted, it is straightforward to foresee an automatic behaviour modeling by employing a rule-based inference system [31].

3.1 Literature Review

This step involves conducting an in-depth review of existing literature on nonverbal behavior, social interaction, and relevant fields of the examined use-case. The goal is to gather a comprehensive understanding of the different types of nonverbal behaviors to extract the nonverbal behavior from. There are several well-documented ways of finding papers for literature reviews and meta-analyses [18]. The scientific criteria utilised in these strategies should also be applied here. They should be well documented for future replicability (e.g., which websites were used, which search words, date of search). The result of the literature review will provide the foundational knowledge required for the subsequent steps.

3.2 Nonverbal Behavior Extraction

After collecting all relevant papers, the specific nonverbal behavior has to be identified and extracted. This requires taking relevant

quotes about, e.g., facial expressions, body movements, gestures, and eye contact directly from papers to preserve nuanced details as accurately as possible. Those are then categorized and described in a spreadsheet with corresponding citations in a structured and standardized manner. This constitutes an abstraction process, as it consists of abstract concepts, which have to be concretised before an implementation into a SIA is possible.

3.3 Nonverbal Cue Operationalization

After extracting nonverbal behaviors, the next step is to operationalize them into actionable nonverbal cues for the SIA. The challenge hereby is to accurately depict the collected research findings. This includes taking the research quotes, transforming abstract behavior into concrete movements and add them to the spreadsheet, which constitutes another abstraction. Afterwards, the spreadsheet contains the abstract nonverbal behavior and the respective concrete movements in a transparent and well structured way.

3.4 Nonverbal Cue Implementation

The list of operationalized nonverbal cues can now be implemented for the specific used animation system. The cues should be examined one by one and individually translated into available animations. This can be challenging and tedious because many existing SIA animation systems only have predefined fixed animations. They need to be individually evaluated whether they actually convey the intended meaning. For example, an animation called "puzzled" is not necessarily categorized by users as puzzled. The end result should be a spreadsheet with directly usable animations and rules as to how to use them. The actual animation process can now easily be done while following the predefined rules.

3.5 Validation

The last step consists of validating the resulting SIA behavior. This step is crucial to actually test the intended effect of customized SIAs. Two separate types of validation should be considered: validation of the accuracy of the nonverbal behavior (experts) and validation of the function of the nonverbal behavior (target population).

4 APPLICATION OF THE MODELIT METHOD

The ModelIT method was applied to the modeling of nonverbal behavior of SIAs that represent people with different attachment styles. The following section does not show the documentation process exhaustively, but it exemplifies the ModelIT method step by step and highlights its importance.

4.1 Literature Review

The goal of the literature review was finding nonverbal behavior of different attachment styles. The first step was implementing a search strategy. Search terms were for example: "attachment style nonverbal", "attachment presentation nonverbal", "attachment style behavior", "adult attachment behavior",... The used sites were "Web of Science" and "GoogleScholar". As one important filter, it was decided to only use nonverbal behavior of attachment style in adults and not children. The chosen categorization system for the SIA was: secure, dismissing, and preoccupied. Importantly, the approach was to utilize literature referring to every attachment style classification system. This strategy was adopted to extract as much information as possible since this particular field of study is not very big. The classification systems are comparable and therefore convertible into each other. The literature review only consisted of collecting usable papers and the different attachment style classification systems were integrated into one coherent taxonomy in a later step. However, it is crucial to note that in different scenarios, such comparability may not hold, necessitating comprehensive documentation of inclusion/exclusion criteria.

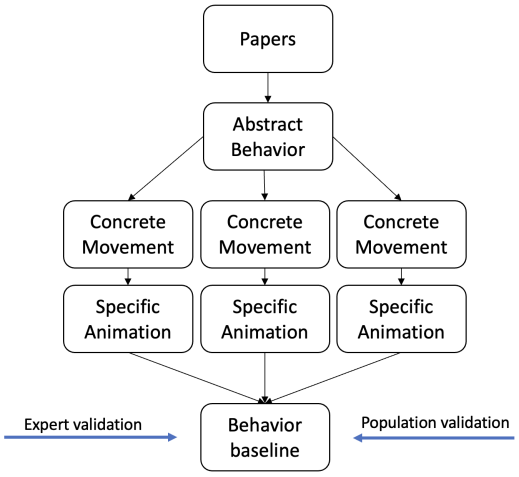

Figure 1: ModelIT method

4.2 Nonverbal Behavior Extraction

The result of the literature review was a list of papers with information about nonverbal behavior for the dimensions attachment anxiety (high) and attachment avoidance (high/low) as well as the categories secure attachment, insecure attachment generally, preoccupied attachment, and dismissing attachment. Those categories were laid out in a spreadsheet and the nonverbal behavior was sorted into this framework quoting directly from the literature.

4.3 Nonverbal Cue Operationalization

The step from abstract nonverbal behavior to concrete movements is very complex due to the nature of the preexisting literature. Nonverbal behavior is often not precisely defined and categorized into replicable movements. They mostly describe nonverbal concepts, that are very ambivalent and need to be operationalized and formalized. A dismissing attachment style for example is associated with less movement in general and less movement complexity [3]. On an abstract level this is a very conceivable concept. But applying it to modelling the behavior of a SIA quickly shows its complexity. The first step is defining a standard frequency this behavior varies from. In this instance, the standard is the secure attachment style. Then you have to decide which movements will be shown less: full body movements, hand movements, head movements, or every kind of movement? Movement complexity is also ambivalent and could apply to many facets and types of movements. Therefore its

Table 1: Example: ModelIt spreadsheet for high Attachment Avoidance

Reference	*Extraction*	*Operationalization*	*Application*
Mikulincer & Shaver (2005) [28]	"blunted affect"	smiles without teeth	emot.smile (not emot.happy)
		neutral facial expression as baseline	emot.bored as baseline
		low frequency of facial expression changes	emot.bored > 80 percent of the time
		only small movements	sad03 (sigh, tiny head-shake, no full-body movement)
Fraley & Shaver (1998) [15]	"frequent avoidant behaviors"	turning away	lookto.right80.01
		looking away from the user	lookat.07.01
		keeping distance hand movement	number.handl.5
		avoiding eye contact	eye contact < 50 percent of the time

modelling has to be standardized. In our case, we chose the standard movement sequences for the secure attachment style and then searched for similar movements with less intensity (e.g., "shrugging motion" as shoulder movement with simultaneous arm movement vs. just shoulder movement). Quantifying "intensity" while working with fixed animations is difficult, and should rely on the consensus of several people within and outside of the direct.

People with generally insecure attachment tend to show discrepancies between verbal content and nonverbal behavior [3]. Therefore there need to be content markers in the spoken text which then have to be contradicted in the nonverbal behavior. This becomes especially complicated when considering the intercultural differences. In a German context a discrepancy is created when the SIA says "yes" while shaking their head. But this would vanish for a Bulgarian SIA, since shaking one's head symbolizes "yes".

The nonverbal markers of attachment style only present themselves in attachment related situations [3]. This needs to be addressed by defining those attachment related situations and labelling them in the action/interaction. This has to done based on attachment style research. The SIA should only display the defined behavior in those labelled sections of the action/interaction.

4.4 Nonverbal Cue Implementation

Every operationalized nonverbal cue on the spreadsheet was matched with available animations in Vuppetmaster[1] – a tool for modelling SIA behavior. This resulted in a detailed and comprehensible spreadsheet that was used to animate videos of SIAs displaying nonverbal behavior of secure, dismissing, or preoccupied attachment.

4.5 Validation

Firstly it must be validated that e.g., dismissingly attached people actually behave in this way. This should be done by experts like psychotherapists and associates of people with dismissing attachment. Secondly, the likeability and trustworthiness of the agents must be validated and rated by people with dismissing attachment.

5 DISCUSSION

In this paper, the five-steps ModelIT method is proposed to model nonverbal behavior in SIAs: (1) literature review; (2) nonverbal behavior extraction; (3) nonverbal cue operationalization; (4) nonverbal cue implementation; and (5) validation. It gives researchers a strong theoretical foundation and transparent guide to ground their modeling of nonverbal behavior in psychological theories.

[1]https://vuppetmaster.de/

5.1 Limitations and Future Work

Often, there is not much information about nonverbal behavior of specific populations in the scientific literature. And, even if there is information about it, it may be vague and/or ambivalent. Therefore, they have to be carefully examined and evaluated when operationalizing them into actionable cues. This should be done as transparently as possible, documenting each consideration and whether it is research-based or consensus-based. A possible other way to gather information about nonverbal behaviors of specific populations is to interview subject matter experts that interact frequently with the specific population. These can be, e.g., therapists working with autistic people. Based on the interview data, the nonverbal cues can be operationalized, applied in SIAs and validated.

Despite best efforts to produce a standardized procedure, it can still (though less) be impacted by human biases. Especially when the team of people modelling the SIA is homogeneous (e.g., concerning cultural background, gender identity,...). This must be counteracted with the proposed thorough documentation making human error at least traceable and therefore (hopefully) solvable. Every modelling of internal states such as feelings through facial expressions is inherently problematic. Feelings are not directly and distinctly identifiable through facial expressions [4], yet they are necessary heuristics for modelling SIAs.

This approach to modelling nonverbal behavior is more time-consuming than automatic generation. But output of the ModelIT method can be used to employ a rule-based inference system for automatic behavior modeling [31]. Additionally, the benefit especially while working with vulnerable populations justifies the additional cost and time investment. Likewise, when working towards a less biased world by considering cultural differences.

6 CONCLUSION

In this day and age, there is a growing need for careful nonverbal modelling to further a barrier-free and intercultural world. Interpersonal differences need to be considered in order to minimize biases and transparent documentation is an essential step towards open science and accessible SIA applications. Therefore, this paper introduced the ModelIT method for modelling appropriate nonverbal behavior in SIAs, enhancing their ability to engage with specific user populations that have been overlooked for too long.

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